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THE

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SOME RECENT EXPERIMENTS IN ELECTROTHERAPEUTICS.

ELECTROTHERAPEUTICS, until a very short time ago, was but a dictionary word, and rarely to be met with outside a glossary of medical terms. Lecturers at the medical schools were accustomed to pass it by with a more or less vague definition, or to indulge in satirical remarks about the prominence given to it by advertising quacks on their business circulars. But now, on every hand, signs are evident that electrotherapeutics is going to be developed into an honourable branch of medicine and surgery, and instead of being practised empirically by a few specialists, at whom their brethren were wont to look somewhat askance, or used by the quack as a thing to conjure with, it will probably before long form part of the usual *curriculum* of every medical student. The new science, as we may now legitimately term it, is attracting very considerable attention in France amongst the medical fraternity, and our contemporaries in that country are recording almost every week some new case of the cure of diseases. In the *Archives d'Electricité Medicale*, Dr. H. Bordier, of Lyons, describes the method by means of which he cured a particularly stubborn case of chronic eczema. He used what he terms the electrostatic method, the patient being put in circuit with the positive wet pole, whilst a pointed electrode was approached to the seat of the disease, a "negative breeze" being thus directed upon it. A Bonetti static machine was used.

In another issue of the same paper the treatment of ozena by means of electrolysis is recently described. This is a very intractable disease, and the results are the more striking, inasmuch as in some cases the patients were under observation for three years after the first treatment, and before the results of this treatment were published. The plan adopted in the treatment of ozena is as follows:—A needle of silver or copper is inserted into the mucosa of the middle turbinated bone, through the bone itself, or else into its concave surface, which is generally the one affected. A steel needle in the mucosa of the inferior turbinated bone of the same side, placed as nearly as possible between the mucosa and the osseous substance, and extending the whole length of the bone itself, completes the circuit. If there is a deviation of the septum, the negative needle is inserted there. We need not follow the writer through his descriptions of how the tissues are anæsthetised, and the instruments, &c., rendered aseptic, but he says that the process is usually painless, and that the lacerated tissues quickly heal. For this form of electrolysis, which is termed interstitial, are needed a source of constant electric energy, a milliampere metre that has been properly tested, a rheostat and needles insulated by means of a bit of rubber tube. In three years it is stated that the percentage of perfect cures has been 91.

Interesting experiments have recently been made, says a writer in *L'Electricien*, in the application of weak electric currents in the treatment of nervous diseases of the stomach. The current is applied directly to the affected organ by means of a special electrode, the invention of Dr. Einhorn (modified by Dr. Ewald), which the patient passes into his stomach. This consists of a rubber tube 1 mm. thick, which has at its lower end a vulcanite tip, and which contains a conducting wire. The patient is first compelled to drink two glasses of luke-warm water, and then the electrode is introduced, and is attached to the negative pole of the battery. From 15 to 20 milliamperes of current are employed for five minutes. It is stated that the success of the experiments have been so marked, that it seems likely to obtain a place in the treatment of the nervous disorders of the stomach and intestines.

THE EIGHT-HOUR DAY.

Our American contemporary, *Dixie*, takes a broad view of the eight-hour day. We rise from a perusal of the article with a conviction that the general hours of work in America must be greatly in excess of what they are here. The conclusion reached appears to be in favour of 10 hours. Eight hours is set down as a doubtful improvement, and 12 or 14 hours is considered too long to work. One thing is certain as regards workshop hours in England, and that is, that shorter hours have shown better results. At Brunner Monds Chemical Works the reduction of the two 12-hour shifts to three shifts of 8 hours, and the consequent employment of 50 per cent. more men at the old rate of wages per week caused a reduction in the wages cost of the output. Each man was paid 50 per cent. higher wages per hour, and yet in one eight-hour day he outstripped his 12-hour self. We believe this is the most striking result yet seen of the benefit of shorter hours. As the work was continuous it was almost a necessity to work each shift either 12 hours or eight, so that no half measure of 10 hours could be tried as a first instalment. Messrs. Mather & Platt, of Salford, and Messrs. Allens, of Sunderland, are, we believe, finding it pay to work only eight hours, which has for years been the rule in New Zealand and Australia, and if others become persuaded that it really does pay to work only eight hours, there can be little doubt but that the short day will become general. We need hardly point out that climatic conditions make an Australian day of eight-hours fully as exhausting physically as 10 or 12 hours in England, and the same applies to American conditions, the climate there being for half the year too enervating, and for the other half, in many parts, too severe except for artificially heated workshops.

We fear that the question of hours is too often made to do duty by unprogressive men as a bugbear in the question of foreign competition, when the real fault lies with their methods, their tools, their attempts at Patriarchal treatment of their employés. The great outcry of bad times in the iron trade has been shown to be anything but a question of hours. It is rather one of old machinery, of excessive royalties, and so on. Obviously, however, for an eight-hour day to be a success there must be a more continuous and sustained effort than is possible with a longer day, and in such a case there is no reason why output should not be maintained, and this really underlies the whole matter, and any employer considering the question must ask himself: Is it likely that eight hours solid work will give me the output of the present longer day of less rigid attention? So far the answer to the question in actual practice has been in the affirmative. Will the effort last? Will a man, newly started on a short day, do more or less in the course of a year when the novelty has worn off? He may do less as the novelty wears off, but again, as his physical condition improves, and there is reason to think that, so far, the increased hours of leisure have not been devoted to unworthy objects, he may, without knowing it, do more work than formerly. Certainly the subject is one that admits of argument and of reason, but there is certainly no occasion for it to give rise to ill feeling as it was wont to do less than 20 years ago, and still does with some. Obviously, the best length of day is that where the output costs least per ton, and the exact length at any particular works is not altogether determined by the endurance of the worker, but varies with the season of the year, with rent and with lighting expenses and ventilation, this latter more than any other being responsible for quality of output.

Photometry of Coloured Lights.

An ingenious and simple method of comparing the luminosities of differently coloured lights is described by Frank P. Whitman in the *Physical Review*, Vol. iii., p. 241. The principle on which Whitman's photometer is founded is due to Prof. Rood. Rood prepared about 50 grey discs differing successively in depth of tint from black to white. If a dark shade was combined with a light shade in the usual way and rotated rather slowly, the familiar unpleasant sensation known as a "flicker" was produced; but if successive pairs, more and more nearly alike, were chosen, the flicker became less, until it almost, or quite, disappeared. Nearly, the same effect was produced if, instead of a gray, some other colour was substituted on one of the discs. It was always possible to combine with it a gray disc of such a shade that the flicker nearly ceased, showing that this sensation is apparently independent of the wave lengths of the lights compared, and dependent only on the relative luminosities. In Whitman's instrument a coloured card and a white card are alternately exhibited to the eye of the observer. These cards are illuminated by lights of different intensities placed at opposite ends of a graduated photometer bar. By moving the support on which the cards are fixed along the photometer bar a point is reached at which the "flicker" ceases. At this point the illumination of the white disc or card is taken to be equal to that of the coloured card, and the relative intensity of the sources of light can be calculated. Of course, instead of a coloured card, a coloured light may be subjected to measurement. This instrument is said to give results quite as good as are obtained when two lights of the same colour are compared by the ordinary photometer.

The Royal Society.—Before this society, yesterday afternoon, after the election of fellows, papers were read as follows:—Professor Dewar, F.R.S., and Dr. Fleming, F.R.S. (1) "On the Electrical Resistivity of Bismuth at the Temperature of Liquid Air." (2) "On the Electrical Resistivity of Pure Mercury at the Temperature of Liquid Air." Professor F. G. Baily: "The Hysteresis of Iron and Iron and Steel in a Rotating Magnetic Field." C. Chree: "Observations on Atmospheric Electricity at the Kew Observatory."

DYNAMOS FOR ARC LIGHTING.

In the early days of electric lighting two well-known "open-coil" machines, which were specially designed for running a number of arc lamps in series, practically monopolised the whole of arc lighting work in the case of extended areas. One great point in favour of both machines was their capability of withstanding a considerable amount of rough usage, and another feature was the effectiveness of their regulators; and it was only when the low efficiency of these machines, as compared with that of ordinary direct-current dynamos, began to be realised, that serious efforts were made to supply current to a number of arc lamps by other means. The fact that it is even now deemed economical to employ "rectifiers" to convert an alternating into a direct current for arc lighting purposes shows that there is still room for a good constant current machine, capable of fulfilling the many exacting conditions demanded of an arc lighter.

It can hardly be said that the attempts which have hitherto been made in England to adapt the ordinary direct current machine to arc lighting work have been successful. The question of regulation has always proved a difficult one, and most of the machines have, sooner or later, given way under the trying work and necessitated lengthy and expensive repairs.

For series arc lighting work it is not sufficient to construct a machine which will develop a pressure of, say, 3,000 volts, with a current of 10 amperes, and in which the general details are similar to those in an ordinary low pressure dynamo, with the solitary exception that the insulation is more effectual. It is, in addition, absolutely essential that the machine shall not only be capable of withstanding the severe stresses due to sudden and enormous changes in the load; but its armature and commutator must be so arranged that repairs whether temporary or permanent can be quickly effected in the event of a breakdown. Now, in order to repair an ordinary armature, it is necessary at the very least to remove the bands round the circumference, to disturb several coils in order to replace a single defective one and subsequently to replace the bands. In fact, the work involved is so troublesome that it is generally impossible to repair an armature, even temporarily, in the engine room, and the only way to avoid a lengthy stoppage is to keep a spare armature in readiness.

In the States the Western Electric Company appears to have made a step in the right direction, by the introduction of a machine which, we should imagine (after a full consideration of the drawings and description), has a fairly high efficiency and is, nevertheless, capable of withstanding as much rough usage and sudden fluctuation in the load as, say, a Brush machine, besides offering exceptional facilities for effecting repairs. The armature is of the ring-wound closed-circuit type, the core discs, which are stamped out with Pacinotti teeth, being driven by a brass spider. The armature is divided into a large number of coils, each consisting of comparatively few convolutions, which gives the advantage of low pressure between adjacent coils; but the most important feature consists in the arrangement whereby every coil is perfectly independent of its neighbours, and any one coil may be removed and re-wound without disturbing any other coil. Each coil is wound in a highly insulating rectangular trough of mica and prepared paper, embracing the core, the ends of the coil being led direct to the extensions from its particular commutator segments. On the outer circumference of the armature the wire, with its insulating troughing, lies in the deep slots formed by the Pacinotti teeth, and wooden wedges tightly driven in over the coil securely hold it in position. This arrangement not only gives the advantage of mechanical strength and protection from mechanical injury, but it enables the usual troublesome bands round the armature to be dispensed with.

We think that every man who has had charge of a plant running arc lamps in series will agree that however desirable it may be to design a machine so that permanent repairs may be easily effected, it is even more important to provide some means for enabling a broken-down machine to be again brought into use within a few minutes, even though it may be able to carry only a portion of its normal load. In the machine at present under notice the large number of independent coils permits of any one defective coil being readily disconnected, and when the armature segments of that coil have been bridged across, the machine can be run with a very slightly reduced output and a slightly increased spark. If the defective coil happens to be short-circuited it must, of course, be removed to avoid the destructive currents which would otherwise circulate in it, and in such a case the coil on the opposite side of the armature must also be removed in order to maintain the mechanical balance. A cold chisel is recommended for the removal of these coils, and it is quite refreshing to even imagine any electrical machine on which a hammer and chisel may be used in case of emergency.

The following set of tests are furnished by the makers of the machine, and, assuming that they may be relied upon, this method of tiding over a difficulty is singularly effective:—

Number coils cut out.	Volts.	Amperes without the use of reducing switches.	Length of spark inches.	Location of coils.
2	4,300	10·4	½	Adjacent.
3	4,250	11·4	½	Adjacent.
4	4,200	12	¾	Adjacent.
8	4,000	11·4	¾	Bunches of 2.
12	3,800	12·2	⅝	Bunches of 3.
16	3,600	10·4	½	4 Bunches of 2 and 8 single coils distributed around the armature.
16	3,600	13·2	¾	Bunches of 4.

It may be mentioned that full advantage is taken of the facilities afforded by the ring type of armature to secure good ventilation.

The commutator segments are insulated by air spaces, and a fair amount of wearing surface is obtained on each segment by making the diameter of the commutator equal to about half the diameter of the armature.

Each machine is provided with a simple and rather neat lightning protector mounted on a slate slab and fixed near one of the horns of the field magnet. An earth-connected carbon plate is placed midway between two horizontal carbon rods connected to the positive and negative leads respectively, and the arc set up by a lightning flash is extinguished by the field from the pole-pieces.

In conclusion, we may say that this machine commends itself to us as a distinct advance in the design of arc lighters, and we venture to think that it is worthy of the serious consideration of makers and users in this country. We shall be exceedingly interested in receiving some reliable information as to its electrical efficiency.

THE EVOLUTION OF MODERN THEORIES OF ELECTROLYSIS.

All science is based on the observation of phenomena which supplies us with facts. The orderly arrangement of these facts, their tabulation and classification, give us descriptive science; whilst the natural questioning of the human mind as to the why and wherefore of these facts, and especially of the observed relation between groups of facts, gives us theoretical science.

Regarding the observed relations between phenomena, a probable guess as to the wherefore of these relations is an hypothesis. When the hypothesis agrees with almost all the known phenomena, explains them naturally and satisfactorily—and, especially, if it be substantiated by rendering predictions which are afterwards verified by observed new facts—it constitutes a theory. And when the theory is so completely proven that no exceptions can be cited to its operation, it then rises to the dignity of a natural law. In regard to our knowledge of the phenomena of electrolysis, we have not yet completely attained this *summum bonum*—this dignity of a natural law: yet our knowledge has certainly gone as far as attempts to explain the observed facts by postulating relations which have not yet been fully proven, and certainly some of our knowledge of electrolytic phenomena has passed into the category of verified law.

At a recent meeting of the chemical section of the Franklin Institute, Dr. J. W. Richards, of Lehigh University, read an exhaustive paper, in which he traced the development of modern theories of electrolysis from the rudimentary notions of Grotthus down to the present day. The first part of his paper was concerned with a review of those facts and proven cases which are necessary to be borne in mind, in order to reach a satisfactory understanding of the latest theoretical views. Consequently, he called attention to what is universally accepted regarding the difference between non-conductors and conductors, and between metallic and electrolytic conductivity, referring to the well known generalisations of Kohlrausch in this direction. Faraday thought he could draw the conclusion from his experiments, that a compound to be capable of electrolysis must contain an equal number of atoms of a different kind in its molecule, and that those which contain more atoms of one substance than of another in their molecule are non-conductors. This has proved to be a very imperfect generalisation, having since been disproved experimentally by exceptions in both directions, whilst modern chemistry has repudiated many of the formulæ on which he based his hypothesis.

Kohlrausch made a generalisation which modern research has, so far, not subverted, but rather confirmed: "No simple unmixed substance is an electrolyte at ordinary temperatures, though many are when heated." The corollary of this is, that "all bodies showing electrolytic conductivity at ordinary temperatures are mixtures of simple substances."

But Faraday, after all, was the first to place on a firm foundation our knowledge of the quantitative relation between the strength of an electric current (its quantity) and its power to effect chemical decomposition. Starting with the idea that chemically equivalent quantities of the elements represent equivalent quantities of chemical combining energy, Faraday's greatest discovery was that "equal quantities of the electric current do an equal amount of chemical work; that is, set free from combination, chemically equivalent quantities of the elements." There is no need to expatiate on this well-known and well-established law. The momentous inference from it was, that a certain definite quantity of electricity appears to associate itself with chemically equivalent weights of the elements, and that each valence, or bond of chemical combining power possessed by an element, appears to require a definite amount of electricity for its dissociation. This law has already done good service in helping to fix the combining power of elements whose valence was in doubt.

However, the *quantity* of an electric current is only one factor in the expression for its energy. Quantity multiplied by intensity equals energy. Amperes multiplied by volts equals work. Faraday knew that there was an intensity factor associated with the decomposition of a compound, but he lacked the grand work of Thomsen in chemical energy and of Joule in electrical mechanics, which would have enabled him to penetrate the maze of this part of the subject.

Since Faraday's time, Thomsen, Berthelot, and the numerous other workers in thermo-chemistry, have measured accurately the heat set free in chemical combinations, and have thus given us thermal equivalents for the energy of chemical affinity. Joule, on the other hand, has given us the quantitative relation between thermal, mechanical, and electrical energy. Thanks to this new science, based on the conversion and conservation of energy, we are now able to understand the exact relations between chemical and electrical energy. We know the chemical energy of a combination expressed in heat energy. We can convert this into electrical energy by means of Joule's constants. But as we already know by Faraday's law, the *quantity* of the electric current taking part in the decomposition of the substance, we have the data from which to calculate the intensity or potential which it must have, since energy divided by quantity equals intensity. We can calculate now the voltage theoretically required to electrolyse any combination of which the heat of formation is known. Further, the electromotive force of any galvanic cell will be given by dividing the algebraic sum of the heat set free in the chemical reactions taking place in the cell (calculated per chemical equivalent of metal dissolved or deposited) by the chemical-thermal equivalent of a volt, which number is 23,040.

Leaving out of consideration the rather wild guesses hazarded in the early days by various philosophers, it may be said that the germ of modern theories of electrolysis are contained in the writings of Grotthus as far back as 1805. Starting with the observed fact that the constituents of an electrolyte appear only at the terminals or electrodes, and that no trace of them in an uncombined state can by any means be detected in the mass of the electrolyte between, Grotthus advanced the idea that each constituent retained its positive or negative character when in combination; that when the terminals are charged by connection with the battery, the attraction of the poles is felt throughout the liquid, so that the molecules, heretofore having their constituents pointing at haphazard in any direction, are polarised by the electric attraction, and arrange themselves in a chain, with their positive constituents all pointing towards the negative pole, and *vice versâ*. This is the idea often referred to as the "Grotthus chain." When the attraction of the poles for the constituent in immediate proximity to them is stronger than the force binding the two constituents together, then the molecule at each pole is disrupted, the constituents are set free at the poles, while an interchange of partners takes place simultaneously along the whole chain, the positive constituent of each molecule uniting with the negative constituent of the next one back of it, and *vice versâ*.

This theory of Grotthus, promulgated in 1805, explained wonderfully well the facts of electrolysis as far as they were then known, and became untenable, only when, in consequence of the acceptance of the dynamic theory of Clausius in 1846, it became necessary to admit that the molecules could not thus be held at rest in a chain, but must be continually in a state of rapid motion. Grotthus's theory would also require that the concentration of the molecules in the solution should remain equal at all points between the electrodes, which is contrary to the facts discovered by Hittorf. The conception, however, on which this century-old theory is based, is still useful in leading up to the later conceptions, which may in some measure be styled only modifications of the older idea, to explain more recently discovered facts.

Clausius's theory as to the dynamic constitution of gases, when extended to liquid and solid bodies, introduced modifications into the conceptions of the *modus operandi* of electrolysis. He assumed that the molecules of a substance are in continual rapid motion, frequently colliding with one another, and probably often exchanging constituents with one another, so that a given atom may be, at successive intervals, united with different other atoms, and not always with the same one as older conceptions fancied. This theory applied to gases, and worked out mathematically, explains so strikingly the fundamental laws of gases, that the truth of its conceptions is verified to a high degree.

(*To be continued.*)

COMPUTATIONS FOR COIL WINDING.

By W. SLINGO and A. BROOKER.

Many writers in scientific periodicals and text-books have struggled more or less effectually with the problem of determining the length and diameter of the wire which, while offering a given resistance, can be wound on a bobbin of given dimensions; as well as the various other problems connected therewith. The question is, perhaps, one which interests the amateur far more than the professional designer of electro-magnets, as the latter generally ignores the complicated formulæ showered upon him—formulæ which profess to take into consideration every possible condition and to give marvellously accurate results—and works by rule of thumb aided by a rough preliminary trial and by the tabulated results obtained in winding many coils of various sizes and types. In the rare cases in which a formula is employed, it is usually taken as representing the *maximum* amount of wire which it is theoretically possible to wind on the bobbin, and the percentage of space which must be added to allow for irregularity in winding, variation in the diameter of the wire, &c., is deduced from the experience already gained in dealing with similar wire. In fact, we regret to say that, although electro-magnet coils with fairly thick wire (such as

dynamo field-magnet coils) are usually carefully wound, small coils with comparatively thin wire are generally wound "anyhow" until the last layer but one, when the irregular surface is covered with a sheet of stiff paper of the same colour as the insulating material, and over this paper the last layer is carefully wound, producing to the eye a charming effect, but defying every formula yet produced.

Although the subject is, therefore, not so important as it might at first sight appear, we are tempted to review the various points involved, as questions connected therewith, are frequently cropping up both in these columns and in those of other scientific periodicals; and, further, the matter has recently been dealt with at some length by Mr. J. B. Baker in the New York *Electrical Review*, in a manner which we do not consider at all satisfactory.

The first formula of any importance which Mr. Baker sets before us professes to give the number of convolutions of insulated wire of a given diameter which can be wound on a bobbin of given dimensions.

The formula is:—

$$N = \cdot 577 \frac{(D - d)(L)}{W^2},$$

N being the number of convolutions, D the external, and d the internal diameter of the coil, L the length of the bobbin between the cheeks, and W the diameter of the wire over all; and from this is deduced another formula, giving the length of wire which can be placed on such a bobbin.

Remembering that actual experiment constitutes the very best test of any formula, we selected a bobbin, and, having measured the space available for wire, we selected some insulated wire, gauged it exactly in accordance with the instructions given by Mr. Baker, and cut off the length indicated by the formula. The wire was carefully wound until the bobbin was full, when it was discovered that there was sufficient wire left to fill another similar bobbin. We then determined the diameter of the wire by our own method, re-applied the formula, and cut off a fresh length of wire, which proved sufficient to fill the bobbin, with one-sixth of the length to spare. Results far more startling were obtained with another formula which professes to determine the diameter of the wire which should be selected under given conditions. Consequently we came to the conclusion that, although Mr. Baker may be a fair prophet in his own country, he is hardly able to cope with the conditions existing here.

The first cause of error is due to the method of determining W, the diameter of the wire outside the insulating covering. We are told to take this reading when the wire is "tightly squeezed in the micrometer callipers;" but this instruction is evidently entirely wrong, as any good micrometer or mil gauge has a very fine pitched screw, and it is easy to squash up the insulating covering of the wire to any extent when turning the milled head with only the tips of the fingers, and so to obtain any reading we please. In fact with thin *bare* copper wire, it is easy to thus cause an error of from 5 to 20 per cent. We do not know why this remarkable method of gauging the wire is recommended, but possibly it is supposed that the wire is squeezed up by the adjacent convolutions when it is wound on the bobbin, and that, therefore, it should be gauged when squeezed up by the callipers. It is not possible, however, when coiling the wire, to materially reduce its effective diameter by any fair means, and if a micrometer or mil gauge is used for the purpose of determining the diameter of insulated wire, the gauge should be set at approximately the right point, and the exact position found by passing the covered wire gently between the faces, adjusting the screw until the experimenter can feel that the wire just touches both faces. A micrometer gauge is, however, not at all necessary, and, indeed, the diameter of covered wire (that is to say, its effective diameter when coiled) can be more accurately determined by winding a length of it on a cylindrical rod, and, after pressing the convolutions close together, measuring the space which they occupy along the rod. This distance divided by the number of convolutions at once gives the diameter of the wire. Thus, if 100 convolutions extend over a length of $3\frac{1}{2}$ inches, the diameter of the wire is $\frac{3 \cdot 5}{100} = \cdot 035$ inch, or 35 mils (the mil being the one-thousandth part of an inch).

We recommend this method of determining the diameter of any wire to amateur coil winders, plumbers, gas-fitters and other similar pillars of the electrical industry—pillars who so often sigh, and sigh in vain, for an expensive wire gauge.

The second cause of error is due to the assumption that when the wire is evenly wound over a layer already in position, it falls into the grooves between the adjacent convolutions of the existing layer, and so increases the quantity of wire which can be wound in a given space by about $15\frac{1}{2}$ per cent. We reproduce fig. 1, which was given with the object of

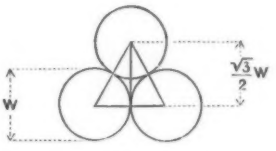


Fig. 1.

proving this point, the three circles representing the cross-section of three convolutions of wire. If the convolution in the upper layer did not fall in this manner into the groove formed by the two lower convolutions the distance between the centres of the wires forming the two layers (that is the thickness of the layer) would be equal to W, the diameter of the wire. But if the state of affairs shown in the figure really does exist, the lines joining the centres of the three circles form an equilateral triangle, each side being equal in length to the diameter of the wire, and the vertical distance between the middle points of the two layers is then equal to the length of the perpendicular line. The ratio of this perpendicular line to the side of the triangle is $\sqrt{3} : 2$, and, therefore, the effective thickness of the layer becomes $\frac{\sqrt{3}}{2}$ W instead of W. A moment's consideration however, will show that the wire can only be made to lie in the grooves in the manner indicated when every layer is started from the same end of the bobbin. When the coil is wound in the ordinary way, the wire continually crosses the convolutions of the subjacent layer, and occupies just as much space as if it were square in section, the length of the side of the square being equal to the diameter of the wire. We have proved by repeated trials that this is so, and every attempt made to economise space by causing the wire to lie in the grooves results in an equivalent amount of space being lost in other directions. The effective depth of every layer is, therefore, equal to the diameter of the wire, and consequently not only is the formula quoted above incorrect, but every formula deduced therefrom is likewise incorrect.

The correct formula can be found in a very simple manner as follows:—

In fig. 2, let l represent the distance between the cheeks of

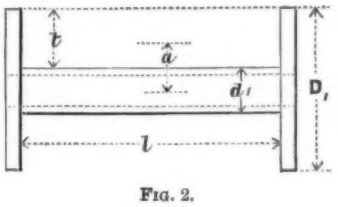


Fig. 2.

the bobbin (or the length of the coil), and t the depth of the coil space (or the thickness of the coil), all measurements being taken in inches. It is evident that in each layer we can wind $\frac{l}{d}$ convolutions, and that we can also wind on the bobbin $\frac{t}{d}$ layers, d being the diameter of the wire over all expressed as a fraction of an inch. Then the number of convolutions per layer multiplied by the number of layers will at once give N the total number of convolutions, that is

$$N = \frac{l}{d} \times \frac{t}{d}$$

or

$$N = \frac{l\,t}{d^2}. \qquad (1)$$

For example, if $l = 2$ inches, $t = \frac{1}{4}$ inch, and the diameter of the wire is 50 mils or ·05 inch, the total number of convolutions will be

$$N = \frac{2 \times \cdot 25}{(\cdot 05)^2} = 200 \text{ convolutions.}$$

In some cases we may desire to fill a bobbin with wire and obtain a given number of convolutions, N, irrespective of the resistance offered by the coil. The diameter, d, of the wire which will give this result is evidently

$$d = \sqrt{\frac{l\,t}{N}} \qquad (2)$$

Should the value thus obtained for d not be exactly one of the standard sizes for covered wire, we should, of course, select the size immediately below d which is available.

The next step is to find, L, the total length of wire of a given diameter which can be wound on any bobbin. The length of any convolution is $2\,\pi\,a_1$ inches, where a_1 is the radius of that convolution in inches. The radius of the convolutions of the middle layer is the *average* radius of all the convolutions, and this average, a (see fig. 2), is equal to $\frac{D_1 + d_1}{4}$, where D_1 is the outside and d_1 the inside diameter of the coil. Consequently the total length of wire in the coil is $2\,\pi\,a + N$, or $2\,\pi\,a \times \frac{l\,t}{d^2}$,

that is

$$L = 2\,\pi\,\frac{a\,l\,t}{d^2} \text{ inches.} \qquad (3)$$

For example, if $a = \frac{3}{4}$ inch, $l = 2\frac{1}{2}$ inches, $t = \frac{1}{2}$ inch, and the diameter of the wire is 36 mils

$$L = \frac{6{\cdot}28 \times \cdot 75 \times 2{\cdot}5 \times \cdot 5}{(\cdot 036)^2} = 4{,}543 \text{ inches, or } L = 379 \text{ feet.}$$

This formula may be used to find the dimensions of the bobbin on which a certain length of wire of given diameter can be wound. Thus, suppose we decide upon the dimensions a and t, and wish to discover l, the required length between the cheeks of the bobbin,

$$l = \frac{L\,d^2}{2\,\pi\,a\,t} \text{ inches,}$$

or we may vary the dimensions in any way so long as the product $a \times l \times t$ remains equal to $\frac{L\,d^2}{2\,\pi}$ inches.

(*To be continued.*)

ELECTRICITY AND THE HORSELESS CARRIAGE.

IF we are to accept the opinion of Mr. W. Baxter on this subject, as set forth in the *Engineering Magazine*, the future of horseless carriages for city use lies with the electrically propelled vehicle. Mr. Baxter arrives at this conclusion on the grounds, first, that steam has been tried and found wanting. This motive power has the disadvantages of noise, dirt, much mechanical complication, and smell, and further, no vehicle steam propelled could be driven in a city by one man only. It would require a man to fire and a man to drive, and he thinks it safe to say that steam never will be made acceptable, whatever it may be in the country, where, as now, it is certain to be largely used, we believe, in preference to other powers for heavy work, as in traction engines for heavy traffic.

Many have believed that the recent improvements in gas and oil engines might solve the problem, but it is considered by our author that this is not an opinion entertained by those who have made electricity a study. He argues that the want of success of steam, and then of gas and oil engines on tramways, is sufficient to stamp them as unsuited to the open road also. In fact, Mr. Baxter demolishes all previous means of propulsion so absolutely, that we fear he is inclined to be a trifle unfair to his enemies in order to push the interests of his friends. Be it understood clearly that it is of city work he is speaking. He makes a great point of the fact that an electric motor will, for a few seconds, put forth an enormous torque, whereas a steam or a gas engine has a limit beyond which it cannot go. That is, a steam engine cannot be forced beyond its maximum capacity without danger to the public. An electric motor with no danger to the public can be safely forced to work at a rate which could not be carried long with safety to the motor, and this ability may mean the power of getting over a particular obstacle that would be insuperable to the steam or gas engine, without special mechanical means of varying the ratio of the gearing, thereby introducing further mechanical complications. He throws cold water on the lightness claimed for gasoline motors, being clearly of opinion that these have been made light with a view to advertisement, and when reduced to commercial sizes, will be found much heavier.

In electrical work a 1-H.P. motor, equal to propelling a vehicle through 1,000 feet per minute, against a 33-lb. resistance, could for a short time be made to exert a 300 to 400 lbs. effort. It could run even several minutes under a stress of 100 or 150 lbs., an increase of capacity absolutely out of the question with gas, oil, or steam. Yet all this, could be done by a motor of extreme mechanical simplicity with one moving part and that a rotary one, and most simple to control. But what of the energy to propel such a motor? The storage battery is alone available, and its past has not been hopeful of the future. The great defect is its inability to discharge rapidly, without seriously increased rate of deterioration.

Thus if a battery requires 10 hours to discharge it, a vehicle must obviously carry weight enough to last 10 hours, but if discharge could take place in one hour, the load would be but a tenth of that in the slower discharging battery. The need is for a battery to discharge rapidly, with, if possible, a less than present rate of deterioration. The present average battery weighs 140 lbs. per H.P. hour, and the discharge period is 10 hours, so that a 2 H.P. motor must carry a load of 2,800 lbs. of cells. A 2-hour discharge would reduce this, if the battery could be halved in weight per H.P. hour, to 280 lbs., and though no such batteries are available, he looks on them as within the limits of possibility; indeed, it is stated that better results have been already secured by the most able workers—we suppose in the laboratory.

About 11 lbs. of material is changed per H.P. hour; the rest of the weight is the cells themselves and their supports, the fluid, and the unused active material.

A reduction to 30 or 35 lbs. per H.P. hour is possible, but not yet probable. The objection of recharging every 20 or 25 miles, at present fatal, would soon cease to be of any account, after it had been absolutely demonstrated that storage batteries were a success. It will be years before electric automobiles can be used for pleasure purposes, so far as being able to run 50 miles into the country and return; but that is not their legitimate field. This is in the express way of the hack or dray. The American origin of the article is evidenced by the claim for the ability of an electric car to get itself out of a hole in a badly paved street, which even a 2 H.P. motor would easily manage, and the stalling of an electric car would therefore be practically impossible. Altogether, the view taken is most hopeful, but it is based entirely on what the future will show in the way of lighter accumulators of much better safe discharging rates.

UTILISATION OF THE MONTMORENCY RIVER.

ALMOST every American paper has reference to some fresh scheme of water power utilisation. The falls of the Montmorency River, in Canada, are now being put to further use. These falls of over 275 feet, only 8 miles from Quebec, were, until 1889, merely used, says Mr. C. C. Chesney, in an interesting article in *Cassier's Magazine*, to drive a cotton mill. In that year, however, the present Montmorency Electric Power Company started a small 100-H.P. plant, with 2,000-volt alternators, and sent current to Quebec at a loss of 50 per cent. up to 1894. At that time the old dam,

about 1,500 feet above the falls, was increased to give 12,000 H.P., and water was lead to a power house by a combination of tunnel, wooden flume, and 72-inch steel pipe, terminating in a receiver. The steel pipe, 1,100 feet long, is simply the down-hill piece of the combination. "Little Giant" turbines are adopted, their unit capacity being 700 H.P., and speed 600, such a wheel only having a diameter of 21 inches, and a length of 2 feet. The station measures 150 × 50, with two floors, one for the wheels, the upper one for the dynamos, with belt connections at 45°. The electrical system is the Stanley-Kelly-Chesney, or S.K.C. two-phase, of Pittsfield, Mass. The phase is 90°, each generator sending alternating currents of 5,200 to 5,700 volts into two independent circuits, the exact potential being given between the above limits of rheostats in the fields. The ~ is 66 per second, the machines being commonly known as 8,000 alternation (per minute) machines, being preferable to the double rate, because of the self-inductive drop in the transmission lines, and while giving greater loss in the transformer cores by 20 to 30 per cent., the regulation is better, and the system more economical as a whole. Two poles by different routes lead to Quebec, one line carrying a pair of 500 kw. conductors, the other one conductor only, as yet. All are overhead, and the poles are wood, with triple petticoat insulators of porcelain. The line is No. 0 B and S bare copper. The ohmic resistance is 8 per cent., increased to 10 per cent. by the self-induction. The extreme tops of the cross arms are connected by a galvanised iron wire, grounded every third or fourth pole with lightning arresters at the ends of each line, and no discharge of lightning into the stations has been known.

The transformers are of 50 kw., connected in pairs wound for 2,500 volts in the primary, and 1,000 in the secondary, so as to receive 5,000 volts, and deliver at 2,000 to the distributing lines. The insulation is tested to 10,000, and in event of one giving way the other transformer can carry the current until the relay transformer can be cut in. There are two sets of transformers of eight each, with a relay to each set.

The generators have stationary armatures weighing 42,580 lbs., and with 5,700 volts and 100 amperes, they are the largest inductor machines yet built. There are 56 armature coils, 28 to each phase, and the revolution speed is 286.

The inductor—a steel casting 43 inches long, 84 inches diameter, and a set of 14 polar projections of iron laminæ at each end, weigh with spindle 28,470 lbs. The whole machine weighs about 100,000 lbs.

Each generator has its own main, and only the transformer secondaries are connected in parallel. Any leakage only affects the particular generator. To keep the machines in step with each other, there is a separate synchronising winding of 120 volts, with a synchronising capacity of 100 kw. The exciters are slow speed 12-kw. direct current machines, each exciting three alternators. For every 100 kw. delivered to the generator pulley 95·1 kw. are delivered to the line and 87½ to the transformers, which in turn deliver the final 86 kw. to the distributing mains. This result is excellent, the total electrical and frictional losses only amounting to 14 per cent.

MOTOR CARRIAGES.

In the *Pall Mall Gazette* of Friday last, there appeared an article from the pen of Mr. F. J. Warden-Stevens, E.E., bearing the above title. We can only guess at the meaning of the mystic letters E.E., but we can say with certainty that the writer's study of the motor carriage business has been of the very shallowest description.

It has always been a marvel to us that journals of the standing of the *Pall Mall Gazette* do not make it a *sine quâ non* that their writers on technical matters should be men who are practically acquainted with the subject they profess to dilate upon, for although the editor of a newspaper cannot be expected to know whether an engineering article is technically correct, he ought to be able to discern whether it is based on practical experience, or whether it is a mere compilation, which the average journalist could undertake, from published descriptions of apparatus, and the trumpet-flourishing prospectuses of public companies.

That the article of Mr. Warden-Stevens belongs purely to the latter category is evident at a glance, and we shall therefore be doing a public service in showing up his lamentable lack of knowledge of a subject which is of the greatest possible interest, but which requires at least an elementary acquaintance with mechanical traction to justify any attempt to deal with it at all, unless, indeed, the sole object of the writer is to try and influence the unsuspecting public to subscribe liberally to a few ventures which are best left severely alone. It will, we think, be generally admitted that there is no higher authority on the question of self-propelled vehicles than Sir David Salomons, for he has had practical experience of virtually all the mechanically driven carriages in the market, experience gained by personal manipulation of the apparatus. This being the case, we will first deal with some of Mr. Warden-Stevens's puerile contentions by the very graphic method of parallel columns.

Extract from *Pall Mall Gazette*:—

The simplicity of driving motor carriages makes a skilled attendant unnecessary, as after a little practice any ordinary person can drive one with as much ease, if not less than driving a horse.

The oil motor, which seems to have achieved the greatest success, so far, is the Daimler. In the Daimler motor an automatic float system is used instead of a vaporiser for feeding the oil to the explosion cylinder; thus no attention is necessary to this matter. The engine is governed by the exhaust, which stops the action of the cylinders. About four gallons of cooling water is sufficient for a run of six hours. The motor is generally fitted at the back of the carriage, suspended from flat springs, and its operation is very simple.

Extract from Sir David Salomons's pamphlet "Self-Propelled Traffic":—

I was so pleased with the carriage * that I ordered one to be built for my own use, that I may entrust any ordinary coachman with the task of driving it, which I should hesitate to do with my Peugeot carriage. It is right to mention, however, that Messrs. Peugeot are dispensing with the Daimler engine, which may now be regarded simply as a connecting link with the past, on account of its numerous valves, some 12 or 14 in number, and the close proximity of the parts, which render cleaning and repairs difficult, besides which the high speed renders a complicated form of gearing or belting necessary, in addition to which are the tube ignition lamps, which require attention.

The Daimler engine is so troublesome to start and to keep in order, that I was led to commission M. Delmer to build another carriage for me.

Extract from *Pall Mall Gazette*:—

Electric power would be the most suitable for self-propelled carriages on account of the absence of smoke, dirt, noise, and vibration, and the facility with which it can be handled; but the great drawback at present is the weight of the accumulators which have to be carried, although there are many inventors working in this direction with the object of reducing it; and I am of opinion that this will be the power of the future for horseless carriages. It will be seen that the chief points where improvement is necessary are the simplification of the controlling arrangements and variable speed gear.

Extract from Electrical Review, May 29th:—

Our contemporary, *Commerce*, publishes this week an account of the interview between "Hermes" and Sir David Salomons. The chairman of the City of London Electric Lighting Company, Limited, says that if the fullest scope were given to electricity, it would be quite impracticable for road motors, except for quite short journeys, and in places where charging stations existed. The weight of any kind of storage battery is so great in proportion to the power developed, that in order to fit a road carriage with it for, say, a journey of 60 or 70 miles, would require an enormous affair, quite out of proportion to its possible utility. "So that electricity is practically out of it altogether for the present?" queried the messenger of the Gods. "Decidedly, for real work," was the reply.

* M. Delmer's carriage, which employs the Benz motor.

Extract from *Pall Mall Gazette*:—

Mr. Radcliffe Ward has worked for some considerable time on this subject, and has had an electric omnibus running in the

Extract from Electrical Review, May 22nd:—

As we have already said, the comparison is based on what has been done by one 'bus running at less than two miles per day

streets of London at a saving over horse omnibuses. This vehicle weighed 3½ tons, and was capable of being easily started, stopped, and steered accurately. It travelled at the rate of about seven miles per hour, the cost per mile run being less than 3d., which, compared with 5d. per mile, the cost of running a horse-drawn omnibus, represents a considerable saving; and of course, as the electric 'bus travels more quickly owing to its greater ease of manipulation, its earning power is increased.

Extract from *Pall Mall Gazette*:—

The London Electric Omnibus Company has been formed with the object of acquiring the patents of Mr. Radcliffe Ward, and has been registered with a capital of £250,000, in £1 shares. This company is the outcome of the Ward Electric Company, Limited, which was registered in 1888, and may now reap the benefits of its early experience. The Universal Electric Carriage Syndicate, which was registered with a capital of £5,000, in £1 shares, in September, 1895, was formed with the object of acquiring the patents taken out by Mr. Bersey relating to electric carriages, but has now been purchased by the Great Horseless Carriage Company. The largest motor carriage concern is the Great Horseless Carriage Company, which has recently been incorporated. The capital is £750,000, two-thirds of which is to be used in purchasing the British Motor Syndicate patents, the remainder being used as working capital. Large works are being equipped for the manufacture of these vehicles, and this company will have the control of the leading English patents relating to oil-motor carriages. Numerous other small companies have been formed, but those mentioned are of most importance.

over a period of eight years, against 911 road cars each doing 66 miles per day for six months, which would give each one a total of 12,000 miles for that period. The question arises as to whether maintenance of accumulators, motors, and gear is based on what was actually spent on the electric omnibus during its long period of easy work. Obviously wear and tear would be very different in a vehicle doing two miles a day and one accomplishing 66.

The estimate put forward seems to be in other respects unsatisfactory. If the cost per 'bus mile can be kept down to 2·44d., then there is little doubt that electric omnibuses will prove successful, but we want something more than 5,000 miles × 2·44d. = £50 extending over a period of eight years to prove it. We feel that the various items put down for fuel, motive power, wages, may also prove illusive. At any rate, before one would feel justified in accepting them, one would have liked some specific figures as to capital cost of engines, generators, motors, accumulators, &c., and the percentage allowed for depreciation, especially on the latter portion of the plant, but we have nothing but speculative lump sums, each covering several items, and in the face of previous accumulator experience on various tram lines, we have no proof that Mr. Ward's 'bus will not in the long run cost as much as the 5·32d. of the London General Omnibus Company.

Extract from Sir David Salomons's pamphlet, "Self-Propelled Traffic."

As in the case of all petroleum engines, it is a great question if anyone came to a Court of Law, whether any single point could be upheld in any one of them.

I cannot too strongly impress this upon the public, that they may not risk their money in patents, which so rarely have any value, and which, in the case of horseless carriages, are absolutely worthless. This I state unhesitatingly, not because it is impossible that on some special point a valid patent might be shown, but from the fact that should such a point exist, a manufacturer could "get round it" by many well-known methods. . . . I therefore regard with great suspicion any company which may be formed in this country for the manufacture of these vehicles, professing, as they probably will, to hold extraordinary patents, for which large sums of money have to be paid, and which sums rarely reach the inventors. It is, therefore, well that the investing public, as well as our financial newspapers, should keep a careful watch on any tactics whereby the public may find themselves at a disadvantage. Further than this, even when a financial paper writes in favour of any company of this kind, a careful investor will search the recent issues of that journal, to ascertain whether the concern so well spoken of has been freely advertised, or, in other words, whether the friendly article is really fair, or, in his judgment, has been indirectly paid for.

There is only one other point to which we need refer. Mr. Warden-Stevens tells us that "great improvements have been made in accumulators since Mr. Ward made this experiment, so it is highly probable that before long we shall have a service of electric omnibuses in London." Perhaps he will have the goodness to inform us of the nature of these great improvements! The E.P.S., the Epstein, the Chloride (one type at least), the Elieson, the Jarman and others, have been tried for electric traction, and found wanting. We challenge Mr. Warden-Stevens to name any new accumulator which has been used for a similar purpose since the termination of Mr. Ward's experiments, and found to possess the three essential qualifications for commercially successful traction work.

PHOSPHORESCENCE AND X RAYS IN THE GEISSLER AND CROOKES TUBES.

By F. CAMPANILE and E. STROMEI.

We have communicated to the Acc. di. Sc. fit. e mat. di Napoli (February 25th, 1896), that a spark introduced into the circuit of a Ruhmkorff coil and of a Crookes tube modifies the action of X rays.

We call *positive air spark* the spark introduced between the positive pole and the tube, and *negative air spark* the spark introduced between the negative pole and the tube.

With rigorous experiments we have found that a positive air spark increases the effect of X rays, and a negative air spark diminishes it.

By means of various arrangements, we have also obtained the Crookes phosphorescence and the X rays from the Geissler tube.

The following arrangement (*bipolar inductive*) gives the best results:—

On the outside of a Geissler tube are glued two pieces of tinfoil, which are connected to the poles of an induction coil. These are also in communication with a graduated spark-stand. When the coil acts, at every spark passing between the balls of the sparkstand, a discharge passes through the tube and illuminates it. Contemporarily on the wall opposite to the positive tinfoil appears the Crookes phosphorescence, which is accompanied by the X rays. The Geissler tube in this side is transformed, momentarily, in a Crookes tube, whilst it maintains in the other regions the properties of the low vacuum tubes. In this arrangement the phosphorescence and the effect of the X rays depend upon the length of the air-spark. There is a determined length, which produces the greatest action.

When it is unnecessary to employ Crookes tubes to obtain X rays, the Röntgen phenomena may be produced by using low vacuum tubes without electrodes.

Our arrangements are besides used to concentrate the cathodic rays, and consequently the phosphorescence and the X rays, in a restricted side of a Crookes tube. The concentration was also obtained by employing a magnetic field.

THE WORK OF VAN DEPOELE.

The Van Depoele patents on the one side, and the Tesla patents on the other, may be said to account for the recent business agreement between the General Electric and the Westinghouse Companies in America. The personal achievements of these two men, to say nothing of their personality, is of uncommon interest. Tesla, still in the mid-day of his career, has his future before him. Van Depoele died just as he had entered into that success which he had earned by a life of toil and hardship against the most discouraging influences, and in the face of obstacles that would have entirely disheartened nine men out of ten. Van Depoele was a Belgian, born in 1846 at Lichtervelde. He was compelled by his father to be a cabinet maker, and had to carry on his electrical experiments, for which he very early developed a taste, by stealth. In 1869 he emigrated to America, whither his father followed him, and so concerned was his paternal relative about his "persistent experimenting and wasting of money," that he demanded that his son should sign papers

agreeing to give up electrical experiments altogether. From that time Van Depoele swore that he would devote the whole of his time and money to the study of electricity. He began building dynamos and producing electric light, and soon came the Van Depoele Electric Light Company which was formed in Detroit. In 1880 he moved to Chicago and commercially exploited a direct current electric lighting system. A small two-phase alternating current motor was built by him and exhibited in 1882, and claimed to be the first of this now well known class. In 1883 he designed, constructed, and sold what is believed to be the first 60-light arc dynamo ever produced. He now turned his attention to the applicability of electric power to locomotion, and here, as all the world knows, he made his great mark. Amongst the more important of the earlier installations laid down by Van Depoele, may be mentioned the first overhead conductor street railway in America, which was put into operation at South Bend, Ind., in 1885; the Capital City Railway at Montgomery, Ala., 1886 (the first commercial trolley road); railways at Minneapolis, Minn.; Appleton, Wis.; Detroit, Mich.; Port Huron, Mich.; Seranton, Pa.; St. Catharine and Windsor, Ontario, all in 1886. Binghampton, N.Y.; Fort Gratiot, Mich.; Lima, O.; Wheeling, W. Va.; and Jamaica, L. I., all in 1887. Ansonia, Conn., and Dayton, O., in 1888. Better work would undoubtedly have been done on the early electric railways, but for the irksome conditions imposed. It was at South Bend, Ind., in 1885, that the motors were first placed under the cars and the famous carbon commutator brushes used, which are now employed on electric motors throughout the world; these have solved one of the most annoying problems in connection with the use of electric motors, especially in electric street railway work. Van Depoele's inventions included many systems of current distribution for electric railways, amongst which may be mentioned the closed magnetic circuit, his conduit with the closed (by flexible material) surface slot and thin plow-collector, his tubular conduit with its continuous series of inwardly movable contacts or push-buttons, his electric mail carrier, electrical reciprocating coal-cutters and rock-drills, &c. Van Depoele was a born inventor, and when he had brought an invention to the point where the development could be entrusted to others, he invariably dropped it for something new. In appreciating his life-work, it must be remembered that he developed the electric railway at a time when expert outside assistance was impossible, and when he had to rely upon his own inventive genius for every piece of apparatus. He was told time after time that his ideas were chimerical, and when his first American railway was projected, a well known professor almost frustrated his plans by claiming that two electric motor cars could not be made to go in opposite directions upon the same track. It takes more than ordinary grit to overcome such obstacles as Van Depoele had to contend with, and it is regretful that just as his abilities had been recognised by the most powerful and progressive electrical corporation in America, death should rob the industrial world of his energies. His death was a great loss to the electrical industry everywhere, and we are glad to see that our American contemporaries are just now doing honour, though tardily, to his memory.

SOME REFLECTIONS AND A MORAL.

By R. P. S.

We are accustomed to be told that America is ahead of us in most things pertaining to civilisation, and not least in industrial development. We meet citizens of the United States who not only say so but believe it; and seeing that since the giant convulsion of the Civil War our brethren have been in quiet enjoyment of a territory of unexampled size, fertility, and resources, free from the distracting influences of rumours of wars, shifting fiscal policies, and foreign competition, they have certainly had the opportunity, and, as we commenced by saying, many agree that they have availed themselves thereof, of giving their undivided attention to the latter-day occupation of seeking riches through industrial development.

Certain it is that in the practical conduct of electrical engineering enterprise, the United States had a start on the Old World. We owe them much of our early commercial dynamo machinery, just as we owe them many other good things—the telephone and our weather being amongst the most obvious. Hence, if the English electrical industry has merely a lag of some year or two period behind the American electrical industry, and whither they go we shall follow in a year or two, it is worth a glance across the Altantic to discern if the promised land has more of milk and honey in it than the thorny path the English manufacturer is now engaged in traversing. A glimpse of this kind is afforded us by the recently issued fourth annual report of the General Electric Company, U.S.A., for the twelve months ending January 31st, 1896.

We are not concerned to enter upon a close scrutiny of the published figures, firstly, because there are probably few stock holders of the company in this country to whom such analysis would be of interest; secondly, because being electrical engineers and brothers in arms we prefer to gird up our loins in order to point out what lessons may be learnt for our future guidance, to criticising too curiously the labours of those who are at any rate turning out much good work. We shall, therefore, only touch on such features as are necessary to bring out the moral which would seem to issue from the materials before us.

Five years ago the leading electrical manufacturing interests in the United States were the Edison, Thomson-Houston, Brush, Fort Wayne, Schuyler, and Westinghouse. In 1892 these were, as everyone knows, all, with the exception of the Westinghouse, practically fused into a single proprietary under the name of the General Electric Company. The conception and execution of such a project was worthy of the land of big "combines." If minimisation of competition, immense resources, and ability to regulate and specialise production are qualities which command success in industry, truly the General Electric entered upon its career well equipped for the future. Possessed of several highly organised factories, and such a clientèle and goodwill as to ensure an immense business in immediate prospect, it appeared to promise fulfilment of the ideal requirements of a successful manufacturing enterprise, viz., specialisation, standardisation, low administrative charges. Launched in 1892, with a capital of about $25,000,000, and a surplus of over $9,000,000, it attained to the full development of its policy in the following year, when the capital account rose to about $45,000,000. Its factories and manufacturing plants then stood in at over $11,000,000; debtors $13,000,000; investments in affiliated enterprises $15,000,000; patents and franchises (a polite synonym for "goodwill") $7,600,000; cash $3,800,000. These figures are without precedent in electrical enterprise; and should afford a valuable lesson on the debated economic question as to whether the "big" concern is the only form in which productive or distributive enterprise can be expected to survive in the future. Here at any rate was a Juggernaut in dimensions with which no small fry could be expected to stand collision in the struggle for industrial success.

What happened? In the following year to January 31st, 1894, the published balance-sheet showed a shrinkage of the company's assets from $54,000,000 to $33,000,000, and of the liabilities from $53,000,000 to $45,000,000; in other words, a loss on the year's figures of $13,000,000—say £2,600,000. About $10,000,000 of this was apparently due to depreciated values of investments in affiliated enterprises, previously valued at $15,000,000—an all-round shrinkage of, say, 66 per cent.! Next year there was a further loss of over $2,000,000—say £400,000; and this, so far as one can judge by the published figures, was not mainly due to depreciated value of assets, but simply loss on manufacturing. The accumulated losses during the first three years (nearly) of the company's life to January 31st, 1895, thus amounted to over $24,000,000—say, nearly £5,000,000! So far things do not look well for modern industrial economists and believers in "combines."

We now come to the period to which the figures of the recently published balance-sheet relate, namely, the 12 months to January 31st, 1896.

During the year the sales amounted to over $12,700,000, say, £2,500,000. Dynamos and motors aggregating 500,000 H.P. were turned out of the factories, including 8,800 street

car motors, over 90,000 H.P. railway generators, and 6,000,000 incandescent lamps.

These are big results, and we turn with interest to see what profits attend the conduct of such an unprecedented business under the exceptional advantages possessed by the General Electric Company. The total profits figure at $1,388,967, which are reduced by depreciations on capital account to $877,645. On the share capital of $34,712,000 this represents a net profit of about 4 per cent. But analysis of the present balance-sheet with those of previous years, which is difficult owing to changes in the form of the accounts, appears to show that appreciation of the items: "Inventories at factories," and "Stocks and bonds of local and manufacturing companies," represents $772,877 of this total. If this be so, the balance of $104,767 represents the year's profits on the purely manufacturing business. In other words, the net profit on industrial operations apparently amounted to under 1 per cent. on the overturn.

Support is lent to this view of the position by the president's comments in the report, which run as follows:—"The business secured by your company for the fiscal year just closed was less than 10 per cent. greater in value of sales than for the year previous. The actual increase in output of factories . . . . is more than 30 per cent. greater than for the previous year."

"The prices of your company's products have undergone excessive shrinkages in the adverse conditions of the past three years."

"Since the close of the fiscal year a contract has been concluded with the Westinghouse Electric and Manufacturing Company, which embodies a recognition of the patents of each company by the other, and the right, subject to certain exclusions, to a joint use thereof. . . . . It is believed that many advantages will be derived from this contract, especially in eliminating much costly patent litigation, and in the important relations of co-operation in engineering and manufacturing methods."

We have already observed that our concern is not to deeply analyse the figures. The critics of the company say that it was greatly over-capitalised, and point, in corroboration of their faith, to the items of "Patents and franchises," $8,000,000, and to the enormous shrinkage in valuation of "Stocks and bonds in local and manufacturing companies," from some $15,000,000 to some $5,000,000 within 24 months of the formation of the company—when, they say, the original stockholders had had opportunity of "unloading" on the public.

Be this at it may, the significant fact for the industry in this country is the apparent beggarly rate of profit which the most powerful and influential electrical concern in the world is able to earn, even upon its overturn, not to mention its alleged inflated capital account. Seemingly, the competition of a single substantial firm—the Westinghouse Company—(the only alternatives are bad management or deliberate policy), has led to a condition of things in which the company, and therefore probably both concerns, have been engaged in a bitter struggle to undersell one another until one of them should go under the waves from sheer exhaustion.

That they have now apparently swung round to the conviction that co-operation is preferable to competition is a piquant fact full of interest, because of its harmony with what the Germans call the "zeitgeist" of the end of this nineteenth century. We shall follow the result of this change of policy with interest.

Meantime, we who have been watching this battle of giants from what we have heard American citizens describe as our "one-horse" island, may be forgiven if we try to extract a moral from the spectacle they have afforded us.

The United States is, *par excellence*, the birthplace of combination. Rings, trusts, "corners," in everything from land to lard oil, from real estate to rape seed, come and go. A few only, like the famous Standard Oil Trust, remain. That associations in such forms are economically and industrially unsound, and therefore can be of no lasting benefit to the public and the investor, is not likely to cause concern to the order of man who brings them about, his motives not usually being philanthropic.

Combination being in the air, electrical manufacturers may well have thought they too would taste of its latent sweets. The instructive feature is their apparent failure to realise that combination to be effective must be thorough. One important competing interest was left out, and as, presumably, this interest declined at first either to come in or be wiped out, a savage and senseless war of prices waged fiercely for several years, each party trying to tire the other out, until at length they have signed a truce to substitute co-operation for competition in their mutual relations. But the effects of an industrial war are not so easily obliterated. It is not unreasonable to suppose that many genuine investors have been wrecked by fluctuations and fall in value of their holdings; while the industry has been rendered unstable by the uncertain value of the immense stocks of affiliated and other companies in the hands of the large interests, and by the suspicion with which the investing and buying public will regard them for some time to come.

The electrical industry in the United States has thus essayed three distinct paths of—shall we say progress? The first is competition; *à l'outrance*, on survival of the fittest lines. The second is combination (critics say at inflated values). The third, yet to be tried, is competition, tempered and regulated by mutual effort and understanding.

To escape the relentless struggle of the first, the bark of the General Electric Company, heavily laden, has nearly succumbed under the second; what is left is now, as we gather, about to launch on the third.

The electrical industry in Great Britain is still passing through the first stage; and, judging by what we hear and see, the result cannot be gratifying either to the labourers in the field or to the investors in the background.

The moral we draw from the United States is that salvation does not necessarily lie in the second stage. Even assuming combination at strictly conservative valuations of the interests included (which seems as difficult of attainment as a rich man's inheritance of the kingdom of heaven), there appears good reason for holding that the exclusion of a single obstinate interest may, and probably will, render the efforts of those who desire to improve the conditions of the industry null and void of effect.

It is therefore interesting to reflect that the industry at home has already for some little time past been quietly feeling its way towards the stage at which the sister industry in the United States has arrived by another route. The intermediate second stage electrical manufacturers in this country have tacitly ignored as a true solution of their best interests. And we may welcome and sympathise with this identity of conclusion the more because healthy, as opposed to destructive competition, tempered and informed by a spirit of mutual goodwill and understanding among the competing interests, is to the lasting advantage of the great public as well as to that of the parties chiefly concerned.

CORRESPONDENCE.

Secondary Batteries for Electrical Locomotion: Sir David Salomons on Electric Road Cars.

I am receiving complaints of the "abrupt and unsatisfactory," "truncated," &c., termination of my papers under the former of the above headings. Will you allow me to state that, although the *addendum*, "to be continued," was omitted in your last issue, it has been my intention to inflict upon your readers three or four more articles before concluding the series? I have yet to show—or to attempt to show—how, when certain data or requirements have been given, a secondary battery may be *scientifically* constructed—*i.e.*, how the remaining values involved may be calculated in accordance with rigid law, instead of being left to the fancy and convenience of the designer. I have yet to show what economy of weight and bulk can actually be effected, and to definitely indicate means for obtaining greatly increased durability.

The observations of Sir David Salomons, which you reproduce (p. 697) in your "Notes," will do good in one direction, and, I think, much harm in another. They tend to remove from the public mind the utterly unfounded impression (tacitly cultivated in certain quarters) that it is practicable to store within a vehicle electrical energy for "a

journey of 60 or 70 miles," or for a run of more than two or (at the very outside) three hours. But they also tend to produce or to confirm another utterly unfounded impression, viz., that there is no "real work" involved in a daily journey from a suburb into town and back, and that electrical locomotion over long distances will, in the near future, be retarded or rendered impracticable by the scarcity of places in which "charging stations" may be found. Given a demand for them, charging stations will be at least as plentiful as were the old posting houses.

Desmond G. Fitz-Gerald.

American Practice in Polyphase Transmission.

I take the liberty of pointing out a little mistake which has crept into your article concerning "American Practice in Polyphase Transmission," of May 15th.

If $$V = \sqrt{3}\, E_1$$

$C V = \frac{C E_1}{\sqrt{3}}$ is wrong, as you but multiply both sides of the equation by C.

$$C V = C \sqrt{3}\, E_1$$

C being the current in each line, the power delivered to the line is

$$C E_1 = \frac{C V}{\sqrt{3}}$$

The output of the alternator is the power delivered to the three lines, and is three times the power delivered to each. The output is, therefore,

$$3 \times C E_1 = 3 \times \frac{C V}{\sqrt{3}} = 1{\cdot}73 \text{ volts} \times \text{amp.}$$

instead of

$$3 \times \frac{C E_1}{\sqrt{3}}$$

Julian H. Rittener.

Geneva, *May 28th*, 1896.

The London County Council and the Tramways.

Noting your leaderette, and feeling the great importance the question of tramway locomotion is to the City of London, leads me to write to you in the hope of assisting to ventilate this important question.

The wisdom and policy of the Council handling the traction themselves, or placing it in the hands of a syndicate, or allowing it to continue to be worked by the present companies, does not seem to be our province.

My experience leads me to conclude that the Metropolitan tramways may be used to the greatest advantage by considering them in the following manner.

For the lines already laid and that are in good order, the Council would do wisely to sanction the putting up of overhead means of driving; and this would be an economy, until the roadway is worn as to render reconstruction necessary. At such period the overhead tackle may be removed, and a "conduit" or other system put down.

It seems to me it would be an error to incur the throwing away of the present road, and the inconvenience necessary for reconstruction, as the overhead wires need only be temporary.

The Americans, by sanctioning various "conduit" and "closed conduit" systems, are showing that their overhead wires are not satisfactory, nor likely to be continued permanently in their towns.

My own experience for about seven years with Blackpool (which has a conduit system), and in the construction of the South Staffordshire overhead line, and the Liverpool Overhead Railway, leads me to conclude that there is no more difficulty in working a "conduit" system than an "overhead" line. The difference is one of cost in the first outlay, and in the necessity for taking up the present roads and relaying them. The question of cost is not a factor which would overload the tramway costs where traffic is great, as in the centres of large towns, and certainly will not prevent the adoption of conduit driving when taken into consideration against the disadvantages of overhead driving, whilst the slight cost of instituting overhead driving does not form an obstacle against its temporary use, as suggested.

I would suggest the unwisdom of waiting to see carried out any experimental methods. The public should be given the great advantages of electrical driving, by the adoption of overhead wires on the present roads. During the period of this temporary existence, sections of their roads may be worked in such a manner as to develop the final method to be generally adopted, as the roads require reconstruction.

T. Parker, F.R.S.E., M.I.C.E., M.I.M.E., M.I.E.E.

June 1st, 1896.

We have read with much interest the leaders under the above title in your issues of the 15th and 29th ult., and also a letter appearing in your issue of the latter date over the signature of "Cosmopolitan."

The importance of the question now under consideration by the London County Council can scarcely be overrated as affecting not only that large portion of the London community to whom the question of a rapid, cheap, and efficient tramway service is of immense importance, but also from the point of view of relieving the greatly congested traffic of the main thoroughfares through which such tramways run.

That sooner or later horse traction, which hitherto has done such excellent service, must, with the march of progress, give way to some form of mechanical traction is, we think, to those who, like ourselves, have closely studied the question of tramway traction, a matter of foregone conclusion.

In considering mechanical traction as applicable to the London tramways, the steam locomotive need not, we think, be taken into account. The cable system, though excellent under certain special conditions, is not, we think, likely to commend itself for the complicated system of the tramways in London. The experience hitherto obtained in the use of accumulators puts that mode of traction completely out of the field, from economic considerations; and, practically speaking, the question of mechanical traction for London tramways is reduced to the direct form of electrically-transmitted power.

The large experience obtained within the last few years, both in America and on the Continent, as well as in this country, has demonstrated beyond all shadow of doubt the excellent results which are to be obtained with the overhead system of electric traction, both in respect to reliability, efficiency, and economy; but however suitable this system may be to more or less outlying districts, it is improbable that the County Council would ever seriously contemplate the erection of overhead wires in the main thoroughfares of the County of London, and we are driven to the conclusion that the problem will not be satisfactorily solved until the Council have satisfied themselves as to what is the most suitable of the several methods now proposed for placing the requisite conductors beneath the surface of the street instead of overhead.

In considering this subject, one is naturally inclined to study the resnlts already obtained with this mode of traction elsewhere, but in so doing it is most important to remember that in no case has a conduit system been laid under the conditions which would apply in London, or indeed in any of our large English cities.

In England, we have but one example of a conduit system in work—namely, that at Blackpool, where a short length of tramway is laid on the sea front where there is but little vehicular traffic, and where the conditions are obviously entirely different to those which would arise in main thoroughfares with excessive vehicular traffic. The most important system of conduit traction so far constructed is that at Buda Pesth, but here again the conditions are entirely different to those we are considering; the streets are extremely wide for the most part, and the ordinary traffic can be carried on without, to any considerable extent, encroaching upon those portions of the streets which are occupied by the tramways. The construction adopted here is such as to frequently involve very considerable interference with the road surface for purposes of maintenance and renewal of the tramways, and considerable alterations in design would be required to suit the conditions of London. In America, some few examples of conduit tramways have been constructed, but here again it would be unwise to lay too much stress upon what has been done, when considering what is possible for London. An amount of interference with the streets is permitted in America without question, which would not for one moment be tolerated here.

The atmospheric conditions of London introduce special difficulties in obtaining high insulation, and this question of insulation is not only of considerable importance in regard to the economical working of the tramways, but might become a matter of serious consideration in respect to the safety of the public, more especially with those systems known as closed conduit systems where the contact rails or plates are placed on the surface of the streets, and it is quite conceivable that systems which might give excellent results when laid in the drier climates of America or some of the continental cities might prove a dire failure when laid down in the damp climate of this country and in the slime and dirt inseparable from the immense traffic in the streets of our main thoroughfares. No system which either from its construction involves anything in the nature of permanent obstruction on the street surface or for the purpose of maintenance requires undue interference therewith, could be tolerated in this country.

It is obvious that the introduction of mechanical traction in London must be gradual, so as not to dislocate the existing traffic more than is absolutely necessary. If the design adopted for the first section is selected with a due regard to and an intimate knowledge of the conditions under which the tramways have to be operated, but little modification would be required in extending it on the remaining portions of the tramways, and the experience derived from using such a line under the actual conditions of London traffic would alone be a convincing demonstration of the suitability of any such system.

Kincaid, Waller and Manville.

June 1st, 1896.

Electric Traction in London.

Your leaderette on the syndicate's proposal to take over London's tramways—coupled with the letter from "Cosmopolitan"—in last week's issue of the REVIEW, may, perhaps, serve as excuses for a few remarks upon the subject of electric traction in London, more particularly from the technical standpoint. I add this qualification, because it seems to me to be of little or no use at present for engineers to put a spoke in the wheel—so far as the County Council is concerned. When this mighty, but ill-informed, conglomeration of the elect shall choose to look into the question under capable guidance, knowing a little of the possibilities of electric traction, then we may hope to see some reasonable progress made towards an arrangement satisfactory to all parties.

I must, at the same time, confess that there is a better prospect to-day for electric traction in London than there was when Mr. Burns and other prominent members of the Council could foretell no pleasanter reception of overhead wires, than their use by all the housewives along the route as clothes-lines for "hanging the wash" upon. Moreover the Council (and therefore the REVIEW, in adopting the same line of argument) is to be congratulated upon its course of action with regard to the syndicate, for no one with the least practical knowledge of tramway working would fall into such a maze of absurdities as the syndicate's proposals appear to be. What financiers and politicians can do, I know is most remarkable; and when they have had their little say and exhausted their enormous stock of nonsense, there may be some opportunity for the practical man to come along, take up the streets, and equip the lines without any more talk. Meantime he may wait a little, and discuss, as far as seems worth while, the best type of line for the conditions prevailing in London.

Having this in view, I read "Cosmopolitan's" letter with some interest, regardless of the question as to whether he has an axe to grind or not. I suppose we all have, for that matter: I confess to it at once. So far as concerns the system he mentions (I will not say "advocates"), it would be most advisable, for electric traction's sake, that the County Council Highways Committee should be induced to see it, and also to visit Buda Pesth, Lyons, and every other place where a conduit system flourishes, if they can be said to do so. There would probably be no objection, I take it, to their also seeing Bristol, Coventry, and Dublin, and a few out of the thousand and one Continental towns and cities where overhead wires prevail. Committees are not, as a rule, averse to travel abroad.

I can conceive no better object lesson to convince the London County Council and the people of London, through their representatives, of the enormous advantages of trolley wires, all things being considered. There is not a single one of the lines now existing in London which could not be converted into a trolley road with as little annoyance to the public as in the places already mentioned. This is because tramways have been kept out of the central parts of the metropolis; I willingly grant that hesitation is at least advisable before running trolley wires from Victoria Station to Liverpool Street or Mile End, *viâ* Charing Cross and the Bank, although some of us may yet live to see this done. But for the old lines—those now being worked in the suburbs by horses—it seems ridiculous to talk about conduit systems or accumulators at from twice to three times the capital outlay, and working cost of trolley wires, when the conditions are exactly the same as, if not better, than in all the places where trolley roads are most successful.

Conduit systems of the Westinghouse or other similar forms, and even accumulator cars, might be justifiable in crowded city streets, where a broken wire or line defect would create a serious block; but as this kind of a millenium has hardly come to pass yet, wherein the authorities discuss tramways along the Strand, let us say, there is no need to trouble about devising elaborate arrangements like that mentioned by "Cosmopolitan" as being at work in Paris and Lyons. The Claret-Viulleumier system of underground switches always makes me think of the Irishman who spoke disrespectfully of his master's bicycle as that "divil of a whirligig." It is very ingenious, also intricate. Fancy the life of a tramway manager, supervising a system of lines, with 20 miles of track and about 350 switchboards each with 30 odd contacts, buried in the ground with a few hundred miles of connecting wires and cables! It seems preferable to have everything in the shape of a contact above board and visible. The perfection of a conduit system has not been attained as yet, one would think; but I have written enough, perhaps, in a purposeless way.

Another time there may be more to say, for the subject has, as you remark, an overwhelming interest.

Frank B. Lea.

Cable Laying, Stuffed Birds, Beetles and Men.

I trust that my hurriedly (and clumsily) written sentence did not have the effect of preventing your correspondent "R. G. T." from winning his yacht race.

The reference to the order given respectively on an English craft and on a foreign one should, of course, be exactly transposed. The language of the tiller is universally maintained on the former, whereas in the latter case (with perhaps more sense) the order applies to the effect produced on the vessel's course rather than on the general steering arrangements (or helm), of whatever nature.

The result of setting the *rudder* to port, however, is obviously (when going *ahead*) to force the stern of the vessel in a starboard direction, and consequently her nose sets portwards.

The printer's devil is so old a story that he is not introduced here. Moreover, if I were to place my clerical error at his door he might have something to say on the subject!

An Amazonian Faraday.

BUSINESS NOTICES, &c.

Dismissed.—At Marlborough Street last week, Norman M'Leod was charged on a warrant with obtaining credit to the extent of £35 10s. from Richard Aylmer, an electrician, without informing him that he was an undischarged bankrupt. Mr. James, in opening the case, said that Mr. Aylmer had some slight acquaintance with the defendant, and during April last received orders from him for the fitting of an electric light installation at 40, Jermyn Street, nothing being said about his being an undischarged bankrupt. The orders were carried out, and application, without avail, made for payment of the account. Mr. Aylmer made inquiries, and found that Mr. M'Leod was an undischarged bankrupt, and took these proceedings, having first written to the defendant, telling him he would do so if the money was not paid. The case was resumed on Wednesday this week, when a gentleman appeared for the prisoner to pay the money, and the prisoner was discharged.

Auction Sale.—Messrs. Percy Huddlestone & Co. will sell by public auction on June 16th, the entire contents of the Acme and Immisch Electric Works, Ferdinand Street, Chalk Farm, N.W., including engines, boilers, lathes, dynamos, motors, measuring instruments, and a variety of other electrical and general apparatus. For further particulars see our "Official Notices."

Electrical Wares Exported.

Week Ending June 2nd, 1895.	£	s.
Adelaide	17	0
Amsterdam	125	0
Algoa Bay	447	0
Auckland. Telephone mtl.	20	0
Bilbao. Teleg. mtl. ...	468	0
Bombay	45	0
Brussels...	246	0
Buenos Ayres. Teleg. mtl.	252	0
Calcutta	133	0
Cape Town	38	0
Colombo	20	0
Constantinople... ...	13	0
East London	695	0
Freemantle	220	0
Flushing	15	0
Gothenburg	25	0
Hamburg. Teleg. mtl.	16	0
Mauritius. Teleg. mtl.	267	0
Melbourne	190	0
Rio Janeiro. Teleg. mtl.	300	0
Rotterdam	80	0
Shanghai	43	0
,, Teleg. mtl....	89	0
St. Petersburg	69	0
Stockholm. Teleg. mtl.	250	0
Sydney	310	0
Yokohama	98	0
Total	£4,482	0

Week Ending June 2nd, 1896.	£	s.
Albany	38	0
Amsterdam	60	0
Bombay	63	0
Brisbane. Sub. cable ...	1,411	0
Cape Town	180	0
Colombo	107	0
East London	233	0
Gothenburg. Teleg. mtl.	135	0
Melbourne	153	0
,, Teleg. mtl.	294	0
Otago	46	0
Paris	147	0
Rotterdam	10	0
Singapore	34	0
Suez	25	0
Sydney	706	0
Wellington	19	0
Yokohama	138	0
Total	£3,769	0

Foreign Goods Transhipped.

	£	s.
Leghorn. Electric meters	43	0
Bangkok. Electric wares	1,550	0

Bankruptcy Proceedings.—Mr. Ronald A. Scott made an adjourned application for his discharge at the last sitting of the Brentford County Court. The Official Receiver reported that the costs of the bankruptcy had not been paid, and there were absolutely no assets out of which the costs could be paid. In addition to that, the costs of the petitioning creditor amounted to £25 or £30, and they had not been paid. The debtor had converted his business into a company, and the debenture-holders of the company had taken over all the assets, and the debtor had been left to pay the debts himself. After a long hearing, his honour said he would reserve his decision until the next Court; at present, he was inclined to refuse the debtor's discharge. It was an exceptional case, and he hoped cases of the kind would remain exceptional.

Liquidation Notices.—At a meeting of Orme's Electric Signal Syndicate, Limited, held on March 27th, it was resolved to wind up voluntarily, as the company cannot, by reason of its liabilities, continue its business, and Mr. J. Orme was appointed liquidator.

British Thomson-Houston, Limited.—A circular, dated May 29th, states in reference to the resolutions, to which we referred last week, for the reconstruction of this company, that in pursuance of these arrangements, the British Thomson-Houston Company, Limited, has been incorporated with a capital of £240,000, and this company has taken over the business of the old company as a going concern, together with all its assets and liabilities.

Change of Address.—Messrs. Cox-Walkers are removing their Edinburgh branch to more commodious premises at 38, York Place, Edinburgh, where their electric lighting, telephone, colliery signal, and lightning conductor business will be carried on.

Frédureau Light Diffusing Globes.—Messrs. A. and E. Cohen have issued a pamphlet, the principal feature of which is a report by Prof. S. P. Thompson on the applications of the diffusing globes of Mons. Frédureau to electric illumination. The report gives a brief general description of the globes, and a recital of the results actually attained. The professor says that in photometric measurements he has in every case found the globes to be effective in concentrating the light in the desired direction. A table accompanying the report purports to show that a lamp nominally of 16 candle-power was giving only 8 candles in the downward direction until provided with the diffusing globe and reflector, but when so provided it gave a light downwards of 34 candles, being an increase of more than four-fold in the desired direction. The increase was of course obtained by utilising rays that would otherwise have been wasted by being emitted upwards, or in directions where they would produce little result. The report is followed by illustrated descriptions of the globes.

Working Brush Plant.—The second edition of "Instructions for Working Plant Manufactured by the Brush Electrical Engineering Company, Limited," has just been issued by that company, from whom we have received a copy. The title of the book, which is very nicely prepared, and bound in covers with gold lettering, will fully explain the objects of the publication, and give an idea of its usefulness.

ELECTRIC LIGHTING NOTES.

Aberdeen.—The Harbour Trustees want to know upon what terms the Council will supply light required for the Harbour. The Gas and Electric Lighting Committee will consider the question.

Battleship Lighting.—The three dynamos with which the battleship *Renown*, at Devonport, is fitted are found to be insufficient to efficiently light the whole of the vessel. It has therefore been decided to have a fourth set of electric light machinery, and a supplementary estimate of £1,200 has been approved for this purpose. The new dynamo will be capable of generating a 400 ampere current.

Ballymena.—The Town Commissioners have appointed a Committee to look after the lighting of the more important streets by electricity.

Belfast.—An important report on future electric light extensions in the city is to be printed and circulated among the members of the Electric Committee for consideration.

It has been suggested by a Councillor that a refuse destructor plant be put down in connection with the new electric light station.

Brighton.—Upon the recommendation of the electrical engineer, the Lighting Committee has decided to run a supply main to the Pentonville district at an estimated cost of £1,600. On Tuesday Col. Halsted, C.E., Local Government inspector, held an inquiry, *re* application to borrow £35,900 for the purposes of electric lighting.

Bristol.—The Electric Light Committee has decided that all future extensions shall be carried out under the supervision of Mr. Faraday Proctor. It is anticipated that there will thus be a considerable saving in the cost of the work. It is proposed to substantially increase Mr. Proctor's salary on the strength of this intention. We understand that it has not yet been decided whether the building extensions (which will make the station nearly twice its present size) shall be carried out in sections or in one contract.

Cheltenham.—Various small main extensions are being made. The borough engineer is to obtain tenders for a supply of incandescent street lamp pillars. The borough electrical engineer's (Mr. Kilgour) salary has been increased to £260 per annum, and will further advance £20 per annum up to £300.

Crewe.—Among various alterations which Earl Crewe is making at Crewe Hall is an electric lighting installation.

Dundee.—The electric lighting department shows a balance of profit for the year's working of over £1,000. It is proposed to abolish meter rents.

Eccles.—The Council has resolved by 12 votes to 9 to go into committee to consider the electric lighting question in all its bearings.

Exeter.—It has been found necessary to at once increase the capacity of the electric light works, which are to be taken over by the Council at the end of June, and a gas engine and alternator are being purchased.

Hampstead.—Mains are to be laid for private supply in the following roads, or portions thereof:—Greencroft Gardens (cost, £125), Oakhill Park (£28), Primrose Hill Road (£290), and Nutley Terrace (£52).—At the last Vestry meeting, the Electric Lighting Committee stated that the engineer had reported that the Brush Electrical Engineering Company were not prepared to carry out the portions of their tender accepted by the Vestry for the supply of additional plant at the central station, unless their tender for Section A, relating to the steam alternator and switchboard, was also accepted; and the committee had therefore accepted the following tenders in lieu thereof, subject to the usual conditions as to contract, viz.:—Messrs. J. E. & S. Spencer, of Globe Tube Works, Wednesbury, for tank (with thicker plate), and appurtenances, for the sum of £395; and Wright's Patent Heater Condenser Company, of 16, Great George Street, Westminster, for one feed water-heater, and steam pipes, for the sum of £967.—The report which has been prepared on the result of the electric light undertaking up to December 31st, 1896, is to be printed and circulated among the Vestrymen.

Helmington Row (Durham).—The Police Commissioners have decided to consider the lighting question. Electricity is thought about in connection with the decision.

Lambeth.—At the last Vestry meeting, Alderman Hubbard again introduced the electric lighting question. He moved that the resolution passed on April 30th be rescinded, so as to afford the Vestry an opportunity of investigating the results obtained with the electric light by other local authorities, considering whether the terms arranged with Messrs. Sax are the best, and also the question of motor *v.* horse traction. The matter was adjourned, a promise being made that a summary of the contract with Messrs. Sax shall be on the agenda paper at the next meeting.

Melton Mowbray.—The District Council has given permission to the Earl of Dysart to cross and break up the road for the purpose of laying underground electric lighting conductors.

Poplar.—The District Board of Works is to apply for an extension of time under the electric lighting order, also to approach the London County Council with a view to securing the supply of electricity for lighting Blackwall Tunnel.

Newbury.—The Earl of Carnarvon has just had Highclere Castle, near Newbury, also the stables, lighted throughout by electricity, a special plant being laid down for the purpose.

Rotherhithe.—The London Electric Supply Corporation has given the Vestry notice that they intend immediately laying mains in Rotherithe New Road and Bush Road.

Sheffield.—One of numerous improvements to be made at Brunswick Chapel is the introduction of electric lighting.

St. Helen's.—The Local Government Board has sanctioned the borrowing of £10,000 for electric lighting purposes, the sum to be repaid in 25 years. The Town Council think this period insufficient, and are applying for an extension.

Sunderland.—The Electric Light Sub-committee have decided to advise the reduction of the price of electric energy for motive purposes from 3½d. per unit to 2½d. The members also decided to recommend the Highways Committee to lay down additional feeders with a view to providing facilities for the ensuing winter.

South Africa.—From the *British and South African Export Gazette* we gather the following information:—Orders will probably be given out at once for additional electric lighting plant for Maritzburg.—An electrical plant for lighting, pumping, &c., is at present on order for the Balmoral mine.—The electric lighting plant for the works of the Richmond Curing and Canning Company, Richmond, Natal, was supplied through Mr. Hadfield, electric engineer, Durban. The dynamo is of 24 amperes and 65 volts, and is capable of lighting 35 lamps of 16 and 32 candle-power. The lamps in the six refrigerating rooms are specially constructed to withstand the effects of water, after the pattern adopted on board ship, by Hines's insulated wire, covered with wooden casing.—The new mills of Messrs. Newberry & Co., at Ladybrand, Orange Free State, are lighted by 22 lamps of 16 candle-power. The dynamos were supplied by the Electric Construction Company.

Tunbridge Wells.—The Chief Constable has been requested to allow the police to turn off the arc lights and turn on the incandescent electric lights in the streets at midnight.

Tynemouth.—The Town Council has decided to discontinue the electric light in the market, and terminate the services of the engineer and adopt gas.

Wells.—Dr. Hopkinson is to be instructed by the Town Council to prepare plans and specifications for an electric light installation for the town.

Windsor.—The *London Gazette* of May 29th contains notice by the Town Clerk of the intention of the New Windsor Corporation to transfer their powers under the Electric Lighting Order to the Windsor Electrical Installation Company, Limited.

Worthing.—In reply to a communication from Mr. W. R. Tasker, the Council has stated that it is not prepared to consider any proposal for the transfer of the electric lighting order. Steps are being taken to secure an extension of time under the order.

TELEGRAPH AND TELEPHONE NOTES.

Chitral Telegraphs.—An Indian exchange says that telegraphic communication with Gilgit is interrupted, owing to the line about Burzil being swept away by avalanches.

Coast Communication.—The fourth report of the Royal Commission on Electrical Communication with Lighthouses and Light-vessels states that in consequence of the serious difficulties which continue to be experienced in maintaining electrical communication with certain light-vessels on the system now employed, the Commissioners have decided to postpone their final report until attempts have been made by further experiments to overcome these difficulties. There are at present five light vessels, six island, pile, or rock lighthouses, and 40 shore lighthouses around the coasts of the United Kingdom which have been placed in electrical communication with the general telegraph system of the country at the national charge. The Mersey Docks and Harbour Board have also connected for their own purposes five of the lighthouses under their control, and one or two other shore lighthouses have been connected by similar bodies in the United Kingdom, apart from any recommendations from the Commissioners. As far as the lighthouses are concerned the cables which have been laid on the recommendation of the Commissioners have worked satisfactorily; while as regards the cables to the light vessels, the Commissioners find that the returns are not so satisfactory as they had anticipated; but they have reason to believe that many, if not all, of the interruptions referred to in the reports received were due to remedial causes, and their endeavours are being directed to removing those causes, and also to experimenting upon a system of communication by induction, as suggested in the previous report. They defer recommending the establishment of electrical communication with any further light stations until the result of these experiments is known.

Indian Telegraphs.—An Indian contemporary says it is understood that an improvement is shortly to be effected in telegraphic communications in India. No actual reduction in the tariff rates will take place, but the despatch and delivery of deferred messages will be expedited.

The International Telegraph Conference. — The Buda Pesth Conference will be attended by the following British representatives:—Post Office: J. C. Lamb, Esq., C.B., C.M.G.; Cape Colony: H. C. Fischer, Esq., C.M.G.; Natal: P. Benton, Esq, and R. Mackay, Esq.; India: P. Luke, Esq., and B. T. Finch, Esq.; New South Wales: Sir Saul Samuel, K.C.M.G., C.B., Agent-General; Victoria: Hon. Duncan Gillies, Agent-General; South Australia: Hon. T. Playford, Agent-General.

The representatives of the various telegraph companies are the following:—The Marquis of Tweeddale; Lord Sackville A. Cecil; Sir Albert A. Leppoc Cappel, K.C.I.E.; C. W. Earle, Esq.; J. Denison Pender, Esq.; M. Jules Despecher; G. Draper, Esq.; F. E. Hesse, Esq.; W. Hibberdine, Esq.; W. H. Axworthy, Esq.; G. R. Neilson, Esq.; H. St. L. Smith, Esq.; S. Barber, Esq., and C. Burt, Esq.; George Ward, Esq.: Ch. Gerhardi, Esq., and Senor Coromina; E. M. Underdown, Esq., and O. Moll, Esq.; Commodore Suenson and F. C. C. Nielsen, Esq.; W. Andrews, Esq, and F. Moll, Esq.; R. K. Gray, Esq, J. Jeffery, Esq., and W. F. O'Brien, Esq.; Major Alexander Wood, and E. S. Hodson, Esq.; R. T. Brown, Esq.; G. von Chauvin, Esq.

The United States Pacific Cable.—A New York dispatch states that the Committee of Commerce of the House of Representatives has authorised a report to be presented in favour of the Substitute Cable Bill, which provides that the Postmaster-General may contract with the Pacific Cable Company of New York for the construction of a cable from the United States to Hawaii, Japan, and China, *vid* the Medway Islands. It is provided that the President may control the line in time of war. The grants and subsidy for the new cable amount to $100,000 yearly, with the right of way over United States territory.

The Amazon Cable.—In Tuesday's *London Gazette* are given the rates, ranging from 4s. 2d. to 6s. 6d. per word, for telegrams to Souré, Mosqueiro, Pinheiros, Cametá, Breves, Gurupá, Chaves, Macapá, Monte Alegre, Santarem, Alemquer, Obidos, Parintins, Itacatiara, and Manáos on the Amazon.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired.
Brest-St. Pierre (1869, Anglo)	April 6th, 1895 ...	...
Puerto Plata-Martinique ...	Dec. 19th, 1895 ...	...
Ceará-Maranham	April 28th, 1896 ...	...
Monte Alegre-Santarem ...	May 5th, 1896 ...	...
Bissao-Bolama	May 30th, 1896 ...	...
Landlines.		
Trans-Continental line beyond Mazol (Mashonaland) Telegrams for Tohikwawa and Blantyre cannot be accepted.	March 12th, 1896 ...	...
Bolinao-Manila—telegrams are sent by post	May 19th, 1896	...
Communication with Cartagena and Barranquilla, Columbia	May 22nd, 1896.	...
Broome—Perth, West Australia	May 24th, 1896.	May 29th, 1896.

The Telephone in Guernsey.—A Guernsey telegram states that all wires put up since May 13th by the National Telephone Company—even those connecting with the Post Office—were cut on Wednesday morning by order of the parish authorities.

The Pacific Cable Conference.—It is stated that the first meeting of the Pacific Cable Conference is to take place to-day, and Mr. Chamberlain will probably attend. The Australian delegates, Sir Saul Samuel and Mr. Duncan Gillies, are going to Buda Pesth on Monday on business in connection with the International Telegraph Conference. They expect to be away six weeks. Meanwhile the Canadian delegates, Sir Mackenzie Bowell and Mr. Sandford Fleming, will, with the representative of the Imperial Government, collect all the necessary information to enable the Conference to arrive at a conclusion shortly after the return of Sir Saul Samuel from Buda Pesth. Lord Selborne, Under Secretary for Colonial Affairs, has been appointed chairman of the Cable Conference in London. Mr. G. H. Murray, of the Treasury, has been appointed one of the Cable Commissioners.

ELECTRIC TRACTION ON THE THREE-PHASE SYSTEM.

If the electric tramway system at Dublin had no special electrical features the system would have created much interest from the fact that it is the longest and most important electric tramway line that has been opened in the United Kingdom. The tramway system is about 8 miles in length, and there is little doubt that considerable extensions will follow as a mere matter of course. The construction and equipment of the line has been a slow operation. The local authorities are responsible for a good deal of the delay, and the somewhat novel methods adopted may be to some extent urged as an excuse against rapidity. The most distinguishing feature is the employment of a three-phase system of generation, which is entirely new to this country. America possesses several such systems, the most prominent being at Sacramento, Norwich, and Lowell. In the two former instances the three-phase currents are used indirectly for operating railways. There is, of course, considerable differences in systems which are generically termed three-phase. At Sacramento, as well as at Norwich, power is generated by three-phase generators, and transmitted over considerable distances to sub-stations, where three-phase motors receive the energy, and in turn drive ordinary continuous current machines. One of the most interesting developments of the system is the use of a motor generator, or as it is better termed in America, a rotary converter. This is a machine which has on one side collecting rings for receiving the three-phase current, while on the other side is an ordinary commutator which commutates the current into one that is continuous. Lowell, in Massachusetts, possesses such a system, which is said to work in a most efficient manner. The rotary converter, though efficient and obviously a good deal cheaper than the combination of a motor and a generator, has its inconveniences. In the first place, the voltage of the current supplied to the motor must be equivalent to that which leaves the commutator, the ratio of the voltage between the continuous and alternating circuits being 1 : 612 for three-phase machines.* As the three-phase system is only useful in the case of distance transmission, a high voltage is invariable, and as the rotary converter usually feeds the railway system at a pressure of 500 volts, it is obvious that step-down transformers must be placed between the three-phase circuits and the converter. Matters are still further complicated in some American three-phase sub-stations by the employment of electrically-driven blowers, to keep the transformers cool.

Northumberland Road, Dublin, showing Span Wires.

The system at Lowell, already referred to, is said to be the first three-phase plant to be employed directly for street railway service. According to an American contemporary, the problem before the railway company was how to connect its terminus at Lakeview with the car line leading to Nashua, 15 miles away. A three-phase system, after careful consideration, was decided upon, and the principle of the installation is as follows: The three-phase current is generated at Lowell at a pressure of 5,500 volts, and is transmitted partly to a point midway between Nashua and Lowell, and part to a sub-station at Nashua itself. It undergoes at both these points, first a reduction of pressure in static transformers, and then a conversion from the three-phase current in a rotary converter emerging upon the feeder and trolley lines a direct current of 500 volts.

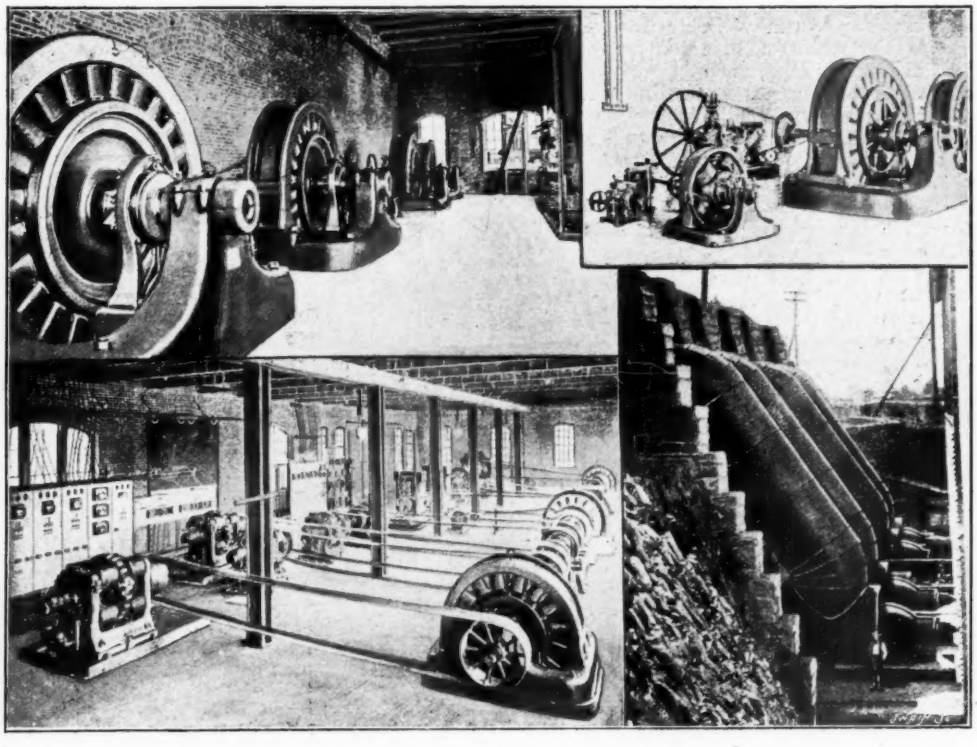
Centre Poles at Dublin.

One of the most quoted long-distance transmission schemes in America—the Folsom-Sacramento—is a three-phase, and as there is considerable similarity between this and the system just completed at Dublin, it may be interesting to include four typical views, taken, by the way, from the *Electrical Journal* of Chicago, as well as to incorporate some remarks on it. There is one great difference between Folsom and Dublin; indeed, our American friends may smile at the comparison, that while the system in the Irish capital is used entirely for tramway work, the Folsom scheme not only operates the Sacramento Street Railway 24 miles away, but lights the town and supplies power for all kinds of purposes. Save that water power is used at the Folsom works, there is no further difference between the two systems. High pres-

* Parshall.

Three-Phase Generators at Folsom.

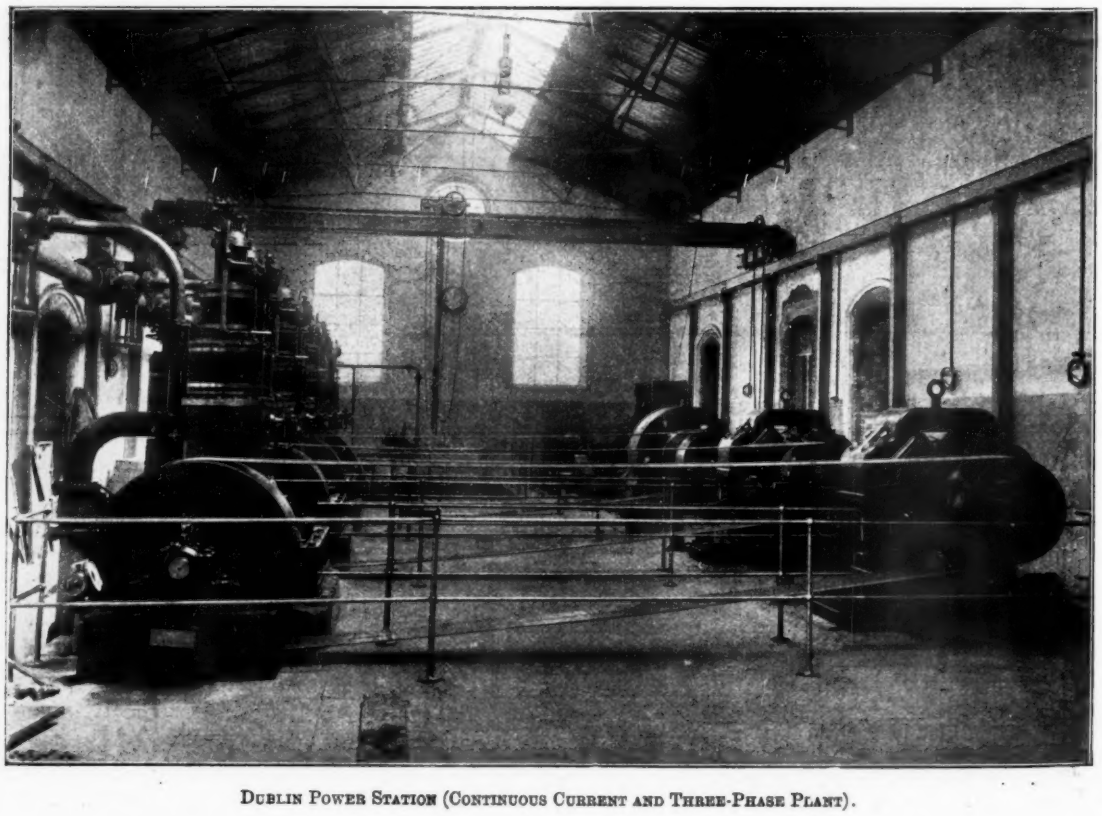
Exciters at Folsom.



Sub-Station at Sacramento.

Penstocks and Turbines at Folsom.

The Three-Phase Plant at Folsom, Sacramento.



Dublin Power Station (Continuous Current and Three-Phase Plant).

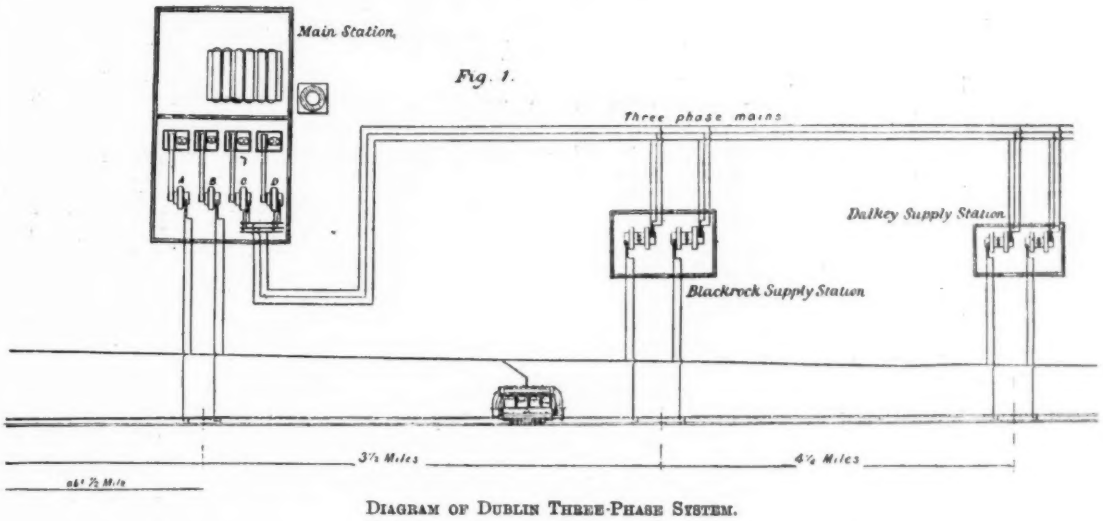
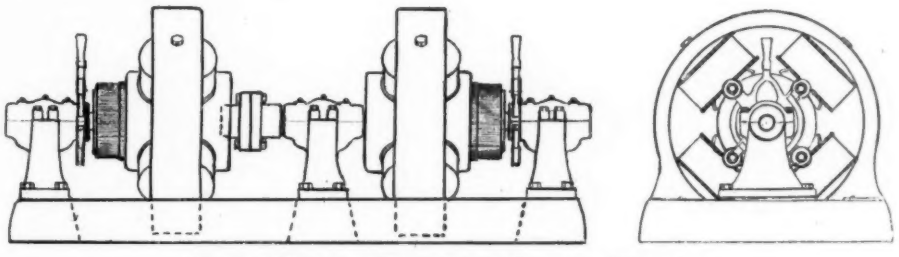
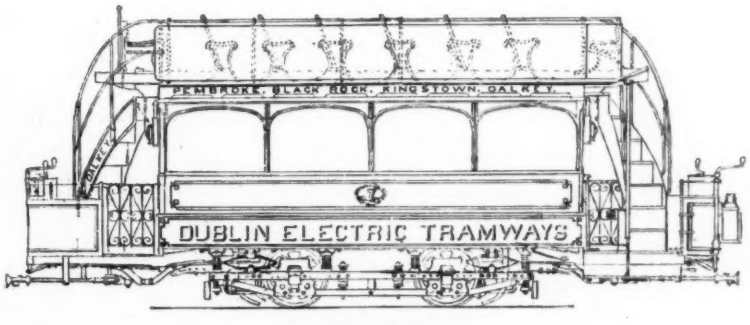


Fig. 1.

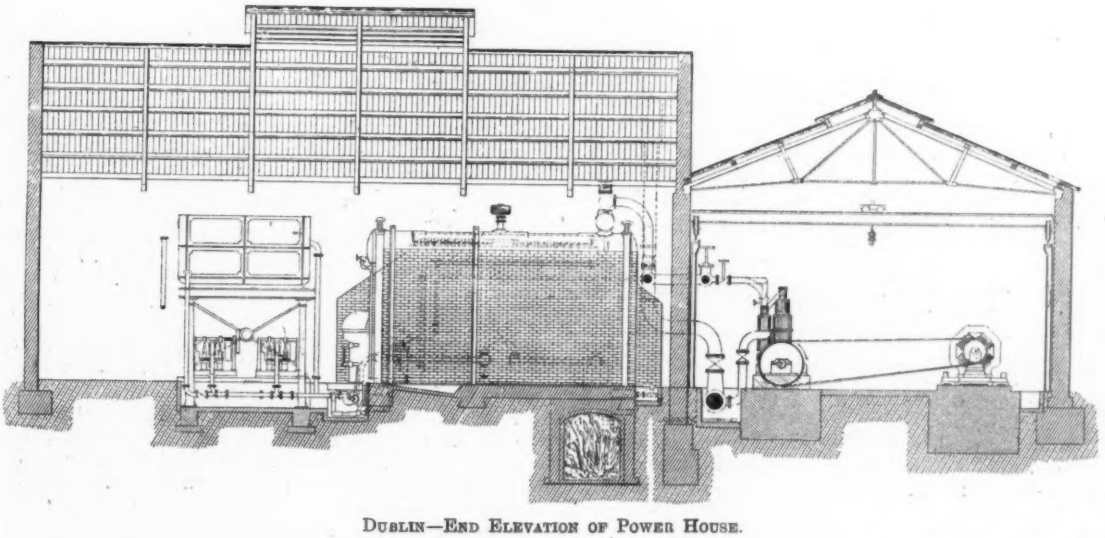
Diagram of Dublin Three-Phase System.



Dublin—Diagram of Three-Phase Motor and Generator.



Section of Car.



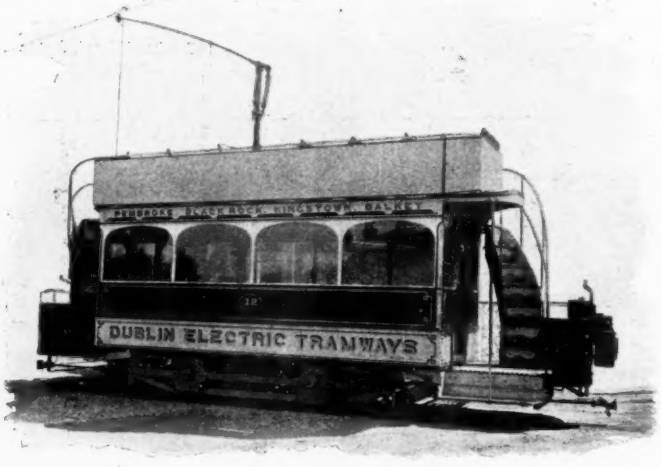
Dublin—End Elevation of Power House.

sure currents pass through overhead lines, and after transformation to three-phase motors at the Sacramento sub-station, where lighting and railway generators are driven.

Perhaps, however, the only real three-phase railway exists at Lugano, that is, where a three-phase current actually drives the cars. It is not very long ago that we gave a characteristic view of the Lugano line. One of the strongest objections against such a system is the necessity of having two overhead wires. Considering that we in this country have the greatest difficulty in obtaining permission to erect one, we are afraid that it is hopelessly out of court.

The following brief extract from the *Electrotechnische Zeitschrift* gives the main features of this line:

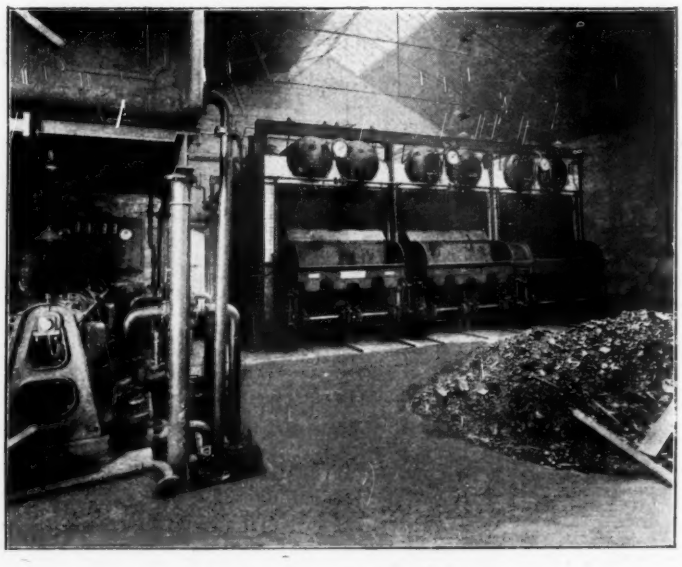
Power is taken from a waterfall 7½ miles from Lugano. This fall already supplies power for the electric lighting of the city on the alternating system, the power for the San Salvatore Mountain Railway, and for industrial uses.



Dublin.—Car on Line.

At the power station is one 300-H.P. turbine, direct connected with flexible coupling to a 150-H.P. three-phase generator. The voltage of the latter is 5,000, the periodicity 40, and the number of revolutions 600 per minute. The arrangement of the generator is such, that the armature remains stationary, and only the iron part of the field magnets rotates. The pole pieces are not set opposite each other, but are staggered. As a result the armature windings are common to both armature cores, that is, they go through both halves of the armature, and each half does not require a special winding.

The current is carried to Lugano on three copper wires, ·2 inch in thickness, and is led in Lugano to a transformer station at about the middle of the railway system. The transformer reduces the potential to 500 volts. The length of the railway is a little over three miles. It has a number of long grades of 3 per cent., and for three short distances as high as 6 per cent. The two overhead wires have a diameter of ·24 inch, and are separated about 10 inches apart. The rails are bonded in the usual way, but without supplementary wires.



Dublin.—View of Boiler House.

The rolling stock consists of four cars, each capable of holding 24 passengers. Each car is equipped with one 25-horse-power motor, which is geared to one axle. The normal speed is about 9 miles an hour. Each car carries two trolley poles, one set about 3 feet behind the other. The resistance is connected to the rotating part of the motor through three contact rings. There is a controller on each platform, where are also hand brake, cut-out, &c.

Lugano, no doubt, is a purely three-phase system, which would, no doubt, work admirably under many conditions. It ought to be mentioned that Messrs. Brown-Boveri constructed the Lugano system, which, so far as we can ascertain, is working most efficiently.

Dublin Electric Tramways.

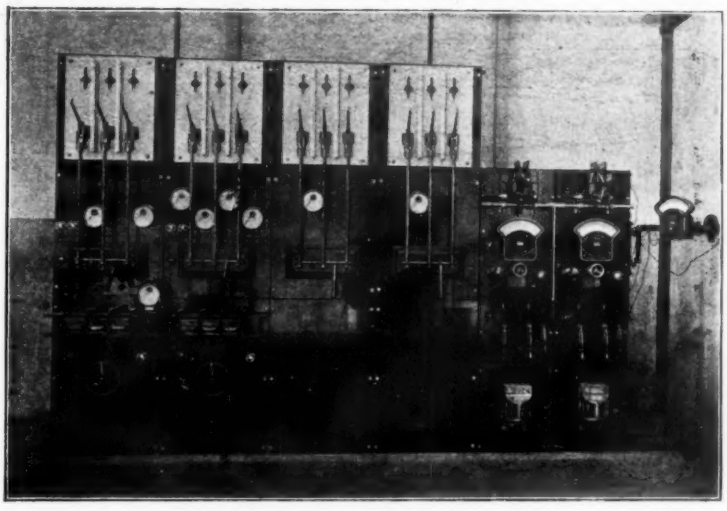
As we have already mentioned, the three-phase system employed on the electric tramway at Dublin is in many respects similar to the Folsom - Sacramento. Three-phase currents are generated at one end of the line, and transmitted by feeders to sub-stations placed at different points, where synchronous motors drive ordinary 500-volt continuous current machines. The exact length of the system is not more than 7¾ miles, and no doubt if a power house could have been erected midway, ordinary direct current methods would have sufficed, but there were difficulties in the way of securing a suitable site, and the fact that the buildings and land of the old tramway company were already existing, it was deemed advisable to erect the main generators at one end of the line, and use a transmission system.

The tramways which have been equipped for electric traction are those controlled by the Dublin Southern District Tramways Company, of which Mr. George White is chairman, and Mr. Clifton Robinson, managing director.

The line extends from the corner of Haddington Road in Northumberland Road, *via* Kingstown to Dalkey. There is a short branch down the Royal Marine Road to Kingstown Harbour, and another branch down the Shelbourne Road leading to the power station (see map of route). The line is fairly level on the whole, the principal gradients being 1 in 29 at Dunleary Hill, 1 in 16 at Temple Hill, and 1 in 23 at Bullock Hill.

The track is double throughout, except for a very short distance between Monkstown Church and Temple Hill, and in the branch line in Shelbourne Road leading to the power station. Contrary to the general practice of America and the Continent, the rails are somewhat light, being 76 lbs. girder rails jointed with massive fishplates, and laid on a concrete foundation. There is again a divergence from what is generally recognised in England in the gauge of the track, which is 5 feet $2\frac{3}{16}$ inches.

The power station is situated in Shelbourne Road by Balls Bridge, adjoining the River Dodder. This position is rather more than ½ mile from the beginning of the line at Haddington Road, and about 7½ miles from the terminus at Dalkey. The buildings are erected on the site of the Old Horse Depôt, the walls of which have been utilised as far as possible. The boiler house measures 56 feet × 56 feet 6 inches; the chimney is 111 feet 8 inches high × 6 feet diameter at the top, and is octagonal in section. The engine room measures 82 feet 6 inches × 32 feet, and is provided with an overhead traveller. The car sheds which adjoin these rooms contain 11 tracks, providing accommodation for about 38 cars. There is also space for 12 more cars in the car sheds at Blackrock and Dalkey. Four of the tracks in the main car sheds are fitted with repairing and cleaning pits. There is also a traversing table provided to enable the cars to be moved from track to track.

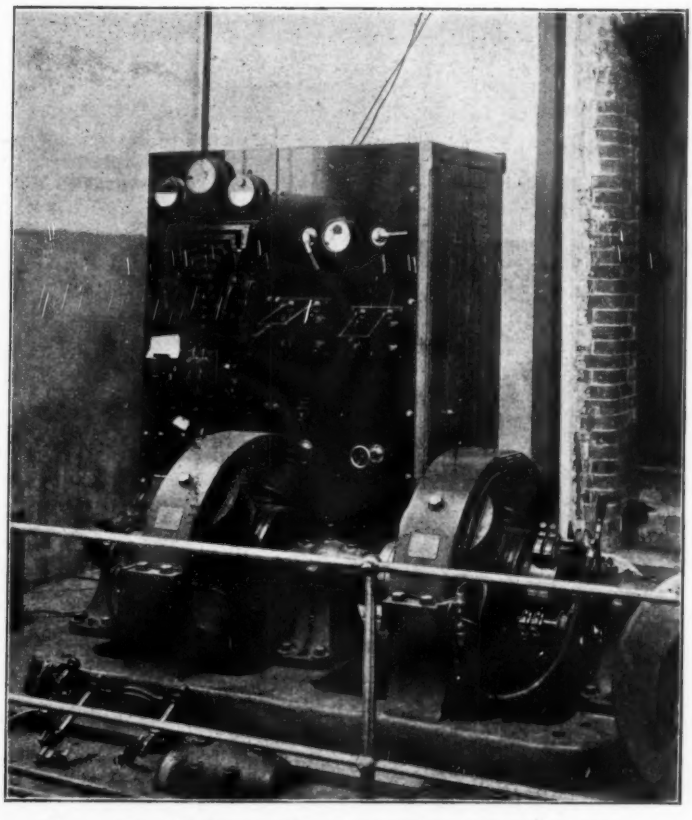


Dublin—Switchboard at Power-House.

There is nothing very unusual in the boiler house, save that it is exceptionally commodious, and very light. A good idea of the arrangement of the plant will be obtained from our illustration. The steam raising plant consists of three Babcock and Wilcox boilers, each of 250 H.P., each, containing 2,437 square feet of heating surface. They are constructed for a working pressure of 140 lbs. per square inch — each boiler being fitted with a Vicars mechanical stoker. There are two three-throw feed pumps, constructed by Messrs. Daniel Adamson and Co., each capable of supplying 16,000 lbs. of water per hour. Each pump is driven through spur gearing by a British Thomson-Houston G.E. 800 motor of the same type as those used on the cars, but shunt wound, each motor being provided with a controlling rheostat starting switch and ammeter mounted on a small panel close to the motor. There is also an injector connected up and capable of feeding the three boilers. The gases from the boilers pass through a Green's Economiser, consisting of 192 tubes. The shafting working the economiser, scrapers, and stoker gearing is driven by a belt from a British Thomson-Houston G.E. 800 motor. These motors, it is interesting to mention, are all operated from the 500 volt tramway bus bars. The engine-room may be roughly divided into two halves, in one of which are the three-phase generators, and in the other are two continuous current machines.

There are four Willans compound engines of H.H.S. size. Each engine is capable of developing 150 B.H.P. continuously, and 175 B.H.P. momentarily when running at a speed of 380 revolutions per minute. Each engine is fitted with variable expansion gear, automatically controlled by the governor. They are each fitted with a belt fly-wheel, 3 feet 10 inches in diameter, and with an outer bearing.

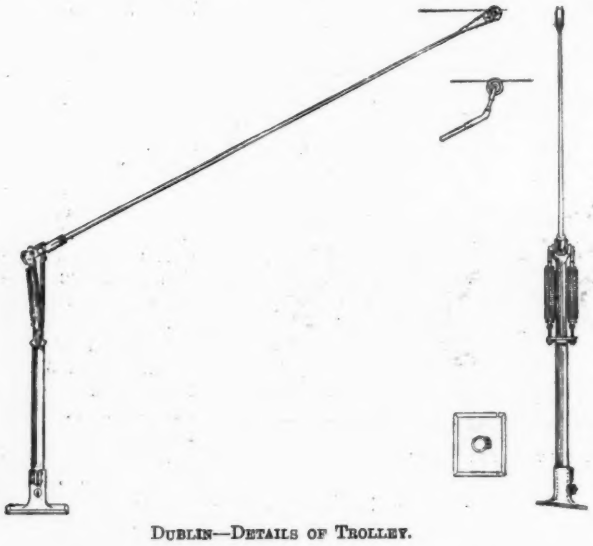
The generators consist of two British Thomson-Houston 100 kilowatt four-pole 500 volts tramway generators compounded to give 500 volts no load, and 550 volts full load, at a speed of 625 revolutions per minute. There are also two six-pole 120 kilowatt three-phase generators wound for 2,300 to 2,500 volts, running at a speed of 600 revolutions per minute. These machines were designed by Mr. H. F. Parshall. It is interesting to mention that these machines were manufactured in England at the works of Messrs. Sir W. G. Armstrong & Co., Limited. The dynamos are driven by means of raw hide leather belts from the fly-wheels of the Willans engines. In one corner of the room there is a British Thomson-Houston 30 kilowatt four-pole motor generator consisting of a shunt wound motor and generator mounted on the same bed-plate and coupled together; the speed is 1,000 revolutions per minute. The motor takes current from the 500 volt station bus bars, and the generator produces current at 125 to 140 volts pressure. This current is used for charging the accumulators and running the station lights.



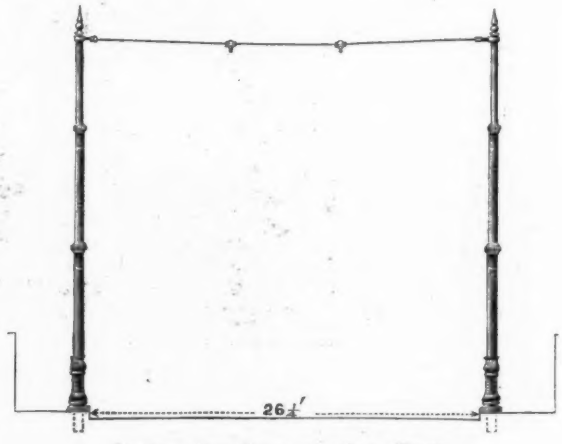
Dublin—Motor Generator and Switchboard at Main Power-House.

Before passing on to speak of the switching arrangements, it will be more convenient if we refer to the accessories of

the steam plant. Close by the motor generator, in a kind of pit, is a condensing plant, which has been constructed by Messrs. Browett & Lindley. It consists of a surface condenser capable of dealing with 19,000 lbs. of steam per hour. The air and circulating pumps are driven by a small vertical engine. The steam piping is arranged in the form of a ring, the main pipes being of wrought-steel 8 inches diameter; the -pieces and bends are of cast-steel, the branch pipes to the engines are of copper, 4½ inches diameter. Hopkinson stop valves are provided in the main ring, so that any engine or boiler may be cut out. The exhaust pipes are of cast-iron, 16 inches diameter, and the branch pipes leading to the engines are 6 inches diameter. The main pipe is connected to the surface condenser, and suitable valves are provided to allow of exhausting to the atmosphere through a length of piping which is carried up outside the walls of the building.



Dublin—Details of Trolley.



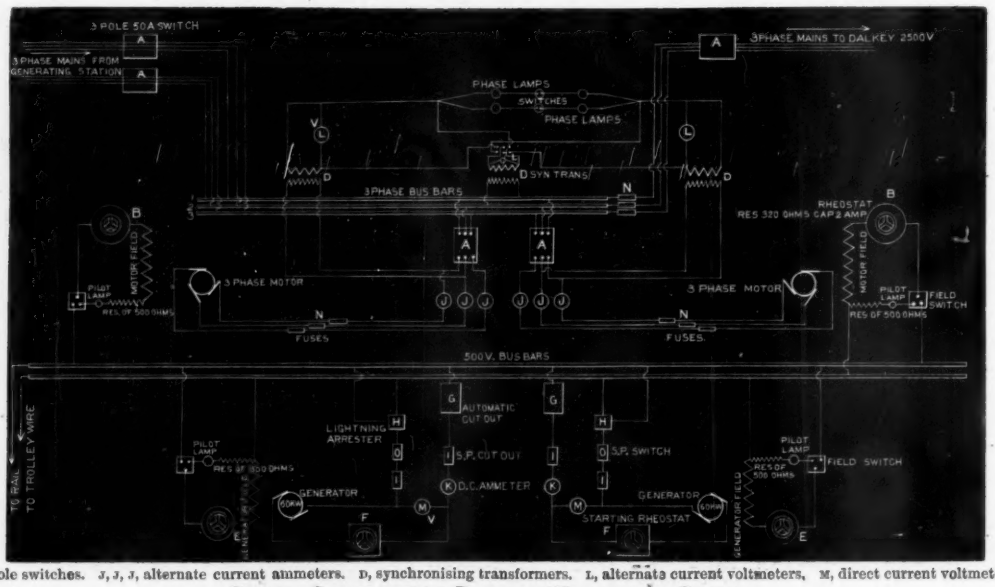
Dublin—Side Poles and Span Wires.

The feed pipes are 3 inches diameter, and arranged so that the supply may be drawn from the storage tank, or from the town supply or hot well. The feed water on its way to the boilers passes through the Green's economiser.

Contrary to one's pre-conceived notions, the switchboard is exceedingly simple, as will be seen on reference to our illustration.

The main generating station which we are now describing does more than supply the three-phase current which is transmitted to the sub-stations, it also supplies an ordinary direct current for a portion of the line; the two continuous current machines already referred to do this, the two small panels on the right of the switchboard controlling the current that is supplied to the line.

The switchboard is arranged on the panel system, a separate panel being provided for each machine. The small panels already mentioned are for the 100 kw. generators, and are of the usual standard British Thomson-Houston pattern, consisting of enamelled slate slabs measuring 90 inches + 24 inches wide, each carrying one automatic circuit breaker with magnetic blow-out and re-setting device; one 300 ampere illuminated dial Weston ammeter; one field rheostat with separate switch connected to resistance to take the discharge current on opening field circuit; one pilot lamp; one voltmeter plug base; two main single pole switches; one single pole switch for series lighting circuit; each panel has in addition a lightning arrester and a Thomson recording wattmeter. The bus bars and connections are carried at the back of the board, and the positive bus bar is connected to



A, 3-pole switches. J, J, J, alternate current ammeters. D, synchronising transformers. L, alternate current voltmeters, M, direct current voltmeters.

Dublin—Connections at Blackrock Transformer Station.

The dynamo and bus bars voltmeters, which are of the Weston type, are mounted on a bracket projecting from the side of the switchboard. The equalising switches are mounted on separate pillars close to the generators. Four separate panels are provided for the three-phase plant—two being for the generators and two for the feeders—the former each carry one three-pole high-tension switch of special design and three high tension fuses of the Ferranti oil break type, 3 Nalder ammeters; 1 voltmeter; 1

the 500 volt trolley wire feeder and the negative bus bar to the rails forming the return circuit.

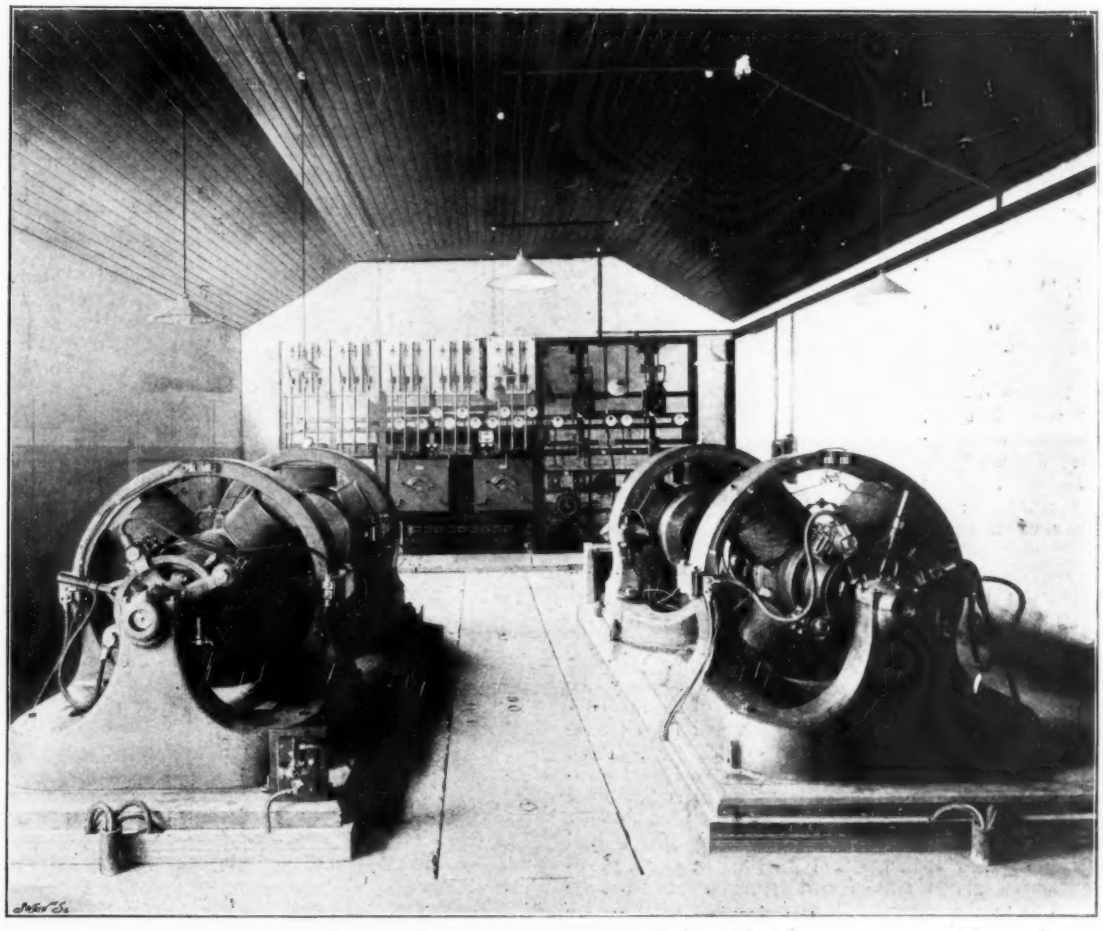
field rheostat and synchronising gear—the feeder panels are each fitted with one three-pole high-tension switch; 1 ammeter. The three-phase generator fields are excited from the 500 volt station bus bars. The above panels, which constitute the main switchboard, are bolted to vertical iron supports, and stand out about 3 feet from the wall. In addition to the above there is a small switchboard at the further end of the engine-room, which consists of two separate panels, one for controlling the high-tension side of the motor-generator and the station-motor circuits, the other carrying the switching gear for the low tension side of the motor generator, the switching gear for accumulators and station lighting circuits. This board is so arranged that the secondary side of the motor generator may be run as a motor when connected to the accumulators, so as to generate 500 volts on the high tension side for operating the station motors when the plant is standing. The cables between the generators and switchboards are of class "L" vulcanised rubber laid in trenches and supported by porcelain insulators.

The battery of accumulators consists of 55 cells of the "R. 11" Epstein type, having a capacity of 600 ampere hours.

Adjoining the engine room is a repair shop fitted with a complete set of machine tools, driven by belts from a countershaft operated by a British Thomson-Houston G.E. 800 shunt wound motor.

The test room is conveniently fitted up with the usual testing instruments, by Nalder & Co., comprising a Post Office bridge with platinum silver coils, D'Arsonval galvanometer, with lamp, scale and keys, battery of 50 accumulators, and a portable Silvertown testing set.

Following the course of the current from the power station switchboard, a reference to the diagram of the line will show the manner in which the power house, the sub-stations, and overhead lines are connected together. It will be seen that there are two sets of mains, one for the 500 volts direct current and the other for the 2,300 volts three-phase system. The 500 volts feeder, which supplies current to the overhead trolley wire, consists of a Callender's lead sheathed and armoured cable—the section of this cable between the power station and Blackrock is ·08 square inch, and from Blackrock to the end of the line at Dalkey ·15 square inch—this feeder being tapped into the trolley wire at every half mile. The three-phase current is carried from the power station as far as Blackrock sub-station by two triple concentric cables. Each of these cables is capable of transmitting the full current required, the other being practically in reserve. From the Blackrock sub-station to Dalkey there is one feeder of the same sectional area. The concentric cables were supplied by the British Insulated Wire Company, Limited, and are of the lead sheathed and armoured type. In addition to these feeders there is a three-core 7/22's Callender's lead sheathed and armoured cable, one conductor forming the test wire, which is connected to the rails at the extreme end of the track, and led into each of the stations, so that instruments may be connected showing the fall of potential on the rails forming the return circuit, the other two conductors being for the telephone system. This cable is led into the feeder switch pillars at every half mile along the line. The mains, both the three-phase and the line feeders, are laid in a specially made trench, which, for the most part, runs underneath the footpath. The feeder switch pillars used by the Thomson-Houston Company were made familiar to our readers when we described the Bristol tramways, those used at Dublin being in all respects similar; they consist of iron casings forming two chambers, the upper one containing a six-way plug switch, to which the 500 volt trolley wire feeder is connected, and also the ends of the two trolley wires on the section insulators, which are fixed at every half mile along the line, so as to divide the trolley wires into sections.



Dublin—Transformer Sub-Station at Blackrock.

By means of plugs, any section of the trolley wire can be completely disconnected both from the feeder and the adjoining sections, and similarly the feeder can be divided into half-mile sections; in the lower chamber of these pillars there is a lightning arrester fixed, as well as a small connecting board for the three-core telephone and test wire cable.

It has been made abundantly clear in the course of this article that the three-phase currents are not commutated, but that they drive synchronous motors, which, in turn, drive direct connected generators. The motors and their direct connected generators are placed in two sub-stations, one being at Blackrock, and the other at Dalkey, the former being 6,000, and the latter 12,600 yards from the power station; both these sites were formerly used by the tramway company as sheds for their horse cars; the car sheds are still retained, and the plant, which is very compact, is placed in a small room adjoining these sheds. The most important of the two is at Blackrock, the arrangements of which are clearly shown in one of the illustrations.

As far as a cursory examination went, this sub-station appears to be excellently arranged, and the motor generators are of the most substantial character. The switchboard seems to be a little complicated; but no doubt most of our readers will be able to follow out the arrangements from the diagram. The plant consists of two direct coupled units, each comprising a synchronous motor coupled to a 60-kw. direct current generator; the motor receives three-phase current at 2,300 volts pressure, and the generator produces current at a pressure of 500 to 550 volts. Taking Blackrock as the general example of the principle on which the sub-stations are operated, it may be said that the three-phase mains are first of all connected to three-pole 50 ampere switches, and from thence the current passes to the three-phase bus bars. From these bus bars connections are made to various instruments and switching gear to the motors. It is important that the motors which drive the railway generators are not thrown on to the three-phase mains before they have arrived at synchronism for the purpose of speeding them up, therefore, arrangements are made for diverting current from the trolley wire to the generator, thus causing it to run as a motor for a short time, and speeding up the real motor till it is in synchronism with the three-phase system. In addition there are on the switchboard switches for controlling the entry of the three-phase current, and the machines switching gear for the 500-volt circuits.

There is very little difference in the arrangement of the Dalkey sub-station, except that the machines are smaller, the generators having a capacity of 50 kw. each.

With the exception of one or two short lengths of line, the whole of the trolley wires are supported on the span wire system. Although the system is perhaps open to more objection than the other methods of supporting the trolley wire, yet the plan adopted at corners for staying the wires is a good deal neater than the earlier importations from America. The effect of the side poles is, however, insignificant, and how little they and the cross wires interfere with the aspect of some thoroughfares may be seen from an illustration of one of the pleasantest roads traversed by the tramway. Where there is a junction of four sets of metals, the overhead work becomes a little cobwebby, but even then very few objections can be urged against it. The variation in the span wire system is on the Royal Marine Road, Kingstown, where centre poles with double bracket arms are used, and for a short distance from the top of Temple Hill, Monkstown Road, Blackrock, where owing to the narrowness of the footpath, it was necessary to use side poles carrying single bracket arms. There are two trolley wires of hard-drawn copper, ·32-inch diameter, stretched the whole length of the line, and a trolley wire is placed over each turn-out and cross-over, and also over the tracks in the car sheds, to enable the motor cars to be moved by power. The poles are made of steel tubes, in three sections, having overlapping joints which are shrunk together while hot. The poles are set 6 feet in the ground, and are surrounded by concrete. A cast-iron base is slipped over the tube, and the pole is surmounted by a finial. Considerable difficulty was experienced in planting the poles, owing to the peculiar nature of the ground, as in many places the rock extends right up to the surface, and had to be blasted out before the poles could be fixed. The span wires are of mild steel cable, $\frac{3}{8}$-inch diameter, secured to the poles by insulated turn-buckles. The trolley wires are suspended by neat insulators of the "West End" pattern, and at every half mile are divided by section insulators, and the ends connected to insulated cables, which are led down the pole to the switch pillars, where they are joined to the switches already mentioned. There are the usual arrangements of overhead frogs and crossings at the junctions and cross-overs, and at the ends of the lines. The rail joints are bonded in the usual way by means of Chicago bonds. Single bonding is employed throughout, and cross connections are made between the rails frequently.

Map of Dublin, Showing Electric Tramway System.

Some idea of the magnitude of the system may be gathered from the fact that the rolling stock at present consists of 20 motor cars of the double-decked type, each capable of seating 24 passengers inside and 29 passengers on top. The length

Dublin.—Double Arm Bracket Pole.

of the car body inside is 16 feet 6 inches, and measures over platforms 27 feet 2 inches. The car bodies were constructed by Messrs. G. F. Milnes & Co., of Birkenhead. The trucks are of the Peckham cantilever extension type, fitted with 30-inch ferro-nickel wheels and axles. The wheel base is 6 feet, and the gauge 5 feet $2\frac{3}{16}$ inches. Each truck is equipped with two British Thomson-Houston G. E. 800 motors, complete with a standard equipment consisting of two K.2. series parallel controllers, which are fitted with special contacts to enable the motors to be short-circuited in case of emergency, thus forming an instantaneous and absolutely reliable electrical brake. There are, in addition, the usual main motor switches, magnetic cut-out, lightning arrester, hand brakes, head lights, and foot gongs. The cars are lighted by five incandescent lamps of 16 C.P. each, run in series off the trolley wire. Electric bells are also provided to enable passengers to signal the motor man. The trucks are fitted with Peckham safety life guards. Although the cross suspension system is employed, the overhead wire does not always follow the exact centre of the track, for the form of trolley will permit of a slight variation, though not provided with a swivelling head. The trolley is mounted on a cast-iron pedestal about 6 feet 6 inches high, which is bolted to a plank running the whole length of the roof. The trolley is placed slightly out of the centre line of the roof, one seat being sacrificed to make room for it. There are in addition 20 trailer cars, each capable of seating 46 passengers; these cars are provided with roof seats, and are similar in design to the motor car bodies, and they are provided with couplings suitable for attaching to the motor cars, and also with gear for horse traction. These cars are fitted with electric bells and lighted by incandescent lamps. Five additional motor cars and ten trailer cars are now being constructed for this line.

The contract for the whole of the generating and sub-station plant, the buildings, reconstruction of the track, rolling stock, cables and overhead line was given to the British Thomson-Houston, Limited, who have carried out the whole of the work.

Mr. C. W. G. Little was the resident engineer for British Thomson-Houston, Limited, acting under instructions received from the head office. Mr. A. J. Ireland superintended a great deal of the construction work, and for the past few weeks Mr. H. F. Parshall has been in Dublin supervising the completion of the scheme, and to test the whole system, and especially the three-phase plant which was designed by him and constructed under his personal direction. The whole of the tests have proved the plant to be most satisfactory in every respect, and the Board of Trade inspectors who examined the line on the 7th ult. have expressed themselves satisfied with the whole scheme, in which they were much interested, as this is the first instance in Europe of three-phase transmission being adopted for tramway working. The line has now been put into regular operation, and is handling a very large traffic with entirely satisfactory results. The number of passengers carried on the first Sunday of operation was 25,000, and a still larger number travelled on the cars during the Whitsuntide holidays.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Aberdeen.—A new tramway line is to be laid down here, and tenders are invited for its construction in Queen's Road and Queen's Road West, extending to 984 lineal yards or thereabouts, for the Aberdeen District Tramways Company, Limited. Plans may be seen and copies of specification and schedule of quantities obtained on payment of £1 1s., which will be returned to *bona fide* tenderers, at the office of Messrs. Walker and Duncan, civil engineers, 3, Golden Square, Aberdeen. Tenders must be lodged at the office of the company, 23, Market Street, Aberdeen, by 9th inst. Possibly the Company would be disposed to consider electric traction proposals.

Austria.—A preliminary concession has been granted for a projected narrow gauge electric light railway between Pergine, in the Pinethal Valley, and Serraglia. Plans are in course of preparation for a further line of electric tramway in Prague, to run between that town and Kuchelbad.

Birmingham.—The Public Works Committee have been considering the tramways scheme, to which we have already referred. Further information regarding the proposals is being prepared.

Bristol.—Mr. Challenger, the traffic manager of the Bristol Tramways and Carriage Company, Limited, informs us that the electric cars on the City and Kingswood line of the Bristol Tramways and Carriage Company, Limited, carried, during Whitsun week, a total of 122,065 passengers.

Cape Town.—We learn that eight of the 25 electric cars ordered for the Cape Town tramways have arrived. They are fitted with all modern improvements, and are of three sizes, varying in carrying capacity from 50 to 80 passengers. Six Westinghouse dynamos, of a compound wound type, have been supplied for the tramways, running at 275 revolutions per minute, and with a capacity of 250 amperes at 550 volts. They require 125 H.P. each to drive them with a full load. They are coupled to the engines, and current is to be supplied direct to the motors.

Chicago Tramways.—From statistics just issued in Chicago, it appears that 10 years ago there were but four tramway companies in Chicago, capitalised at $11,437,000, and working a street mileage of 90 miles. To-day there are 29 distinct corporations engaged in local transportation business, having an aggregate capitalisation of $187,208,000, and operating 342 miles of street mileage. Of the four systems in existence 10 years ago, three were worked entirely by horses, the fourth using both cable and horses. Now the horse car has practically disappeared from Chicago, the motive power at present being:—Surface roads—electric, 255 miles; cable, 42 miles; horse, 18 miles. Elevated roads—electric, 15 miles; steam, 11 miles. In addition to the roads now completed, construction work is rapidly progressing upon five surface and elevated roads, all to be worked by electricity, and which will, when completed, increase the total city mileage to 400 miles. Against these figures it is interesting, says the *Times*, to place the statement that London has less than three miles of mechanically worked tramways, while the total street length of tramways is only 136 miles, all worked by horse power.

European and American Practice in Electric Traction.—The *Street Railway Review* has the following pertinent remarks on the different methods adopted in Europe and America:—"The tendency of American practice is towards standardisation and simplification and cheapening of manufacture and maintenance, and to this is partly due no doubt the rapid growth of the electrical business in this country. The European engineer, on the other hand, must have everything technically correct and suited to each particular case, thereby giving rise to a great diversity of practice and complication of apparatus. An example of the latter was furnished the other day, when an examination of a trolley base sent from Germany, and considered the proper thing over there, revealed the fact that it had something over 100 parts. In spite of the conservatism of European engineers, the fact remains that to them is due the honour of being the first to try many new things. We have in mind now especially the road at Lugano, Switzerland, which is the first commercial street railway to use the three-phase system. It is to be hoped that it is the forerunner of many more, for the practical success of this system means not only a simplification of motors and generating apparatus, but the building of long suburban and inter-urban roads served from one power plant. The three-phase system is not going to drive out the direct current plan of distribution, but has a field of its own to develop."

South African Power Notes.—The *British and South African Export Gazette* understands that Mr. J. Hubert Davies, electrical engineer, Johannesburg, is supplying the West Chimes mines with two Elwell-Parker dynamos of 24 H.P., and a motor by the same makers of 25 H.P.—The electrical plant for the New Heidelberg Roodepoort mine, ordered from Mr. Davies some months ago, will include two 56-H.P. dynamos for lighting and transmission of power, two 20-H.P. Elwell-Parker motors for the cyanide works and workshop machinery, a 30 H.P. Elwell-Parker motor for driving the supply pump, and a 30 H.P. motor for driving the pumping plant. Mr. Davies has also received an order for two 100-H.P. three-phase generators, and three three-phase motors, of 60 H.P., 30 H.P., and 45 H.P. respectively, and the necessary lighting and other electrical accessories for the New Spes Bona mine.—We understand that the electrical plant on order for the New Reitfontein Estate Company consists of a 37 H.P. Elwell-Parker dynamo and a 35 H.P. motor by the same makers.—All the mechanical haulages on the Wolhuter mine are now being re-arranged for electricity as the motive power, and dynamos have been put into the mill engine house.—Electrical transmission will, we believe, be adopted in the unwatering of the East Nigel mine.—The newly-formed Koesterfontein Company proposes, in addition to gold mining, to supply the West Rand properties with electrical power. The expenditure on plant for this purpose is estimated at about £20,000, and it is proposed to supply 1,000 H.P. and to charge the mines £40 per H.P. per annum, power being conveyed by cable to any properties within 20 miles to the east or south-east.

We understand that it is proposed to adopt electric traction on the horse tramways at Johannesburg. The Tramway Company is in negotiation with the local authorities in reference to the matter.

Switzerland.—The scheme for the construction of an electric mountain railway from Zermatt up the Gordergrat is about to be put into execution. The line will be about six miles long. The water power of the Findelenbach is to be utilised in the generation of the necessary electrical energy.

The Cost of Operating Washington Conduit System.—The average cost per train mile on this road is stated to be 9·27 cents, the cost of power per train mile is 1·19 cents, and the cost of car equipment and repairs per train mile is 0·96 cent.

The Westinghouse Magnetic System.—The Turtle Creek branch of the Pennsylvania Railway is to be electrically equipped as an experimental track with the Westinghouse electro-magnetic contact system and the overhead system.

The Central London Railway Company.—It will have been observed, from our frequent reports of cases, that the compensation claims against this electric railway company for compulsory purchase of premises required by the company in the construction of the railway and stations, are very numerous. Another similar case came before the London Sheriffs' Court on Tuesday, in which plaintiff, Mr. Tenchio, owning an Italian restaurant at 13, Stanhope Terrace, Bayswater Road, W., claimed £2,200. A verdict was given, by consent, for £1,150.

The Waterloo and City Electric Railway.—This underground railway is making satisfactory progress towards completion. At Tuesday's meeting of the Commission of Sewers a plan and section of the City station in Queen Victoria Street was received from the engineers and referred to the Streets Committee for consideration.

CONTRACTS OPEN AND CLOSED.

OPEN.

Austria.—June 28th. The last date for the receipt of tenders invited by the Municipal authorities of Prague, for the erection and equipment of a municipal electricity generating station in the town for electric lighting, power, and tramway traction purposes, has been extended from June 1st to the 28th.

Burnley.—June 24th.—The Corporation requires tenders for the supply of armoured concentric underground cables. For further details, see our "Official Notices."

France.—June 16th. Tenders are being invited by the General Direction of the French Posts and Telegraphs for the supply of a quantity of miscellaneous chemical materials for primary batteries, in 12 lots. Tenders to be addressed to La Direction Générale des Postes et des Telegraphes, Rue de Grenelle, 103, Paris.

Glasgow.—June 15th. The Caledonian Railway Company requires tenders for stores for the twelve months commencing August 1st. The following are some of the items:—(2) Bolts and nuts; (18) copper rivets; (29) India-rubber; (33) iron rivets; (34) galvanised wire and wire fencing requisites; (49) screws; (50) shovels, spades, and graips; (52) spelter, tin, and lead; (59) sundries; (60) telegraph and electric appliances; (65) tinwork; (66) tools. Specifications, &c., may be obtained on and after June 1st from Mr. Jas. Lorimer, superintendent of stores, Caledonian Railway, Charles Street, St. Rollox, Glasgow.

Huddersfield.—June 19th. Messrs. Learoyd Bros. & Co. require tenders for the supply and erection of a 92-unit direct-current dynamo, and a 3½-unit combined steam-engine and dynamo, at Trafalgar Mills, Huddersfield. Particulars from Messrs. Shepherd and Watney, 71, Albion Street, Leeds.

Leeds.—June 20th. The Council require tenders for an electric installation for working on the overhead system a 7-mile (double track) length of tramways. A note of the seven sections, poles, conduits, wires, cars, accumulators, &c., will be found in our "Official Notices."

Leicester.—June 6th. Tenders are wanted for the supply of coal cobbles, or nuts, for one or two years ending 31st inst., for the Gas and Electric Lighting Committee. Particulars and form of tender can be obtained on application to Mr. Alfred Colson, M.I.C.E., engineer and manager.

Mexico.—August 31st. The Municipal Council of Mexico is inviting tenders for the concession for the electric lighting of the public streets during a period of eight years.

Saxony.—June 10th. The Saxon State Railway Telegraph Department at Dresden is inviting tenders until June 10th for the supply of 60 tons of galvanised iron wire, 12,000 porcelain insulators, and 8,500 zinc cylinders for batteries. Tenders to be sent to the Königliche Betnebs-Telegraphen-Ober-Inspection, Sächsische, Staatseisenbahnen, Friedrichstadt, Dresden.

Shoreditch.—June 16th. The Vestry invites tenders for the supply and fixing of insulated conduits, cables, switch and fuse boards, &c., &c., for the electric lighting and dust destructor installation. For further details see our "Official Notices."

CLOSED.

Aberdeen.—The Gas Committee has accepted the following tenders for the extension of the buildings at the electric lighting station in Cotton Street, and the plant required:—

Buildings.	£	s.	d.
Mason work—Robert Smith	2,007	0	0
Carpenter work—Watson & Robb	369	0	0
Plasterer and concrete work—Scott & Sellar	586	0	0
Plumber work—John Thom	34	19	0
Painter and glazier work—John Williamson	39	7	6
Slater work—William Coutts	109	10	0
Iron and steel work—James Abernethy & Co.	532	16	0
	£3,678	12	6
Plant.			
Boilers, heaters, pumps, and pipes—W. M'Kinnon & Co.	2,995	0	0
	£6,673	12	6

Cheltenham.—The tender of Messrs. E. Green & Son for a fuel economiser of 150 tubes at £225, has been accepted.

Chichester.—Messrs. Richard Crittall & Co., of London, W., have secured the contract for the electrical installation at the West Sussex County Asylum, Chichester. The contract includes plant, secondary battery, wiring and fittings on the 200-volt system. The consulting engineers are Messrs. Massey & Allpress.

NOTES.

The Electrolytic Manufacture of White Lead.—Mr. R. P. Williams (*J. Am. Chem. Soc.* 17, 835-842) describes the patent process of A. B. Brown for the electrolytic production of white lead. It consists in decomposing, by an electric current, a solution of sodium nitrate, containing about 1 lb. to the gallon, in wood cells provided with porous diaphragms; the nitric acid radical attacks the positive electrode, which is of metallic lead, and the lead nitrate solution thus formed is precipitated later by the sodium hydrate produced at the other electrode. The precipitated lead hydroxide is digested with bicarbonate of soda solution, whereby lead carbonate in a very fine state of division is obtained. The sodium nitrate is thereby regenerated. The sodium bicarbonate used is formed by passing carbon dioxide into the caustic soda solution. It is claimed that the process can be made a commercial success, the white lead being equal or superior to that made by the old "Dutch process." The plant required is small for a considerable output, and there is no loss of time, the reactions taking place rapidly. There is a great saving in labour and materials as compared with the Dutch process. The product of the electrolytic process is in a very fine state of division, and is claimed to be of a spongy character, non-crystalline, and having a greater covering power than Dutch process lead. Tests of durability show this lead to be fully equal to Dutch lead.

The Theory of Lead Accumulators.—We have already had to notice the criticisms of Schoop upon the Darrieus theory of secondary cells. It may be remembered that he raised three principal objections to this theory. In a recent issue of the *Zeitschrift für Elektrochemie*, 1896, page 471, K. Elbs and O. Schönherr reply to these objections. They defend the use of platinum electrodes by showing that *ceteris paribus* more persulphuric acid would be formed on them than on lead plates, and by reiterating their statement that sulphuric containing persulphuric acid will even convert a film of lead peroxide into sulphate. Secondly, they endeavour to meet Schoop's hypothesis based on the possible action of nascent persulphuric acid, by asking how the residue of this acid differs from that of sulphuric acid in moderately dilute solutions? These are well known to peroxidise lead and its salts. The third objection was that they regarded as lead sulphate the white precipitate formed on mixing lead nitrate and ordinary ammonium persulphate solutions, although it rapidly became brown by peroxidation. To this the authors reply that lead persulphate is soluble and easily decomposed, that ordinary ammonium persulphate contains sulphate, and that any lead sulphate formed would naturally become rapidly covered with brown peroxide under these circumstances.

Okonite.—Mr. Fremont Wilson, writing to our New York namesake, says that in the re-wiring operations in a New York building, some old wires insulated with "okonite," which were taken down, had neither a braid nor a tape upon the insulation. The wire had been in place seven years, and was, during all that time, lying directly upon the plastering, in a position where the temperature ranged from 70 to 90° Fahrenheit, and yet this wire showed no signs of deterioration. It was decided to make an insulation test in comparison with a sample of the "okonite" wire bought in the open market. The result of this test was that the old wire stood the test equally well for three days with the sample of new wire purchased. After a seven days' test the sample still showed insulation resistance sufficient to pass the standard requirements of the fire underwriters. Our contemporary publishes a photograph of the piece of wire received from Mr. Wilson.

Electricity in a Bicycle Factory.—The most important customer of the Middletown (Ohio) Electric Light and Power Company is the Miami Cycle and Manufacturing Company, which is situated about a mile from the station. It takes current for 180 horse-power in motors, for 800 incandescent lamps, of which 400 are usually in use, and for six arc lamps. The cycle company turns out about 200 wheels a day, and employs from 500 to 600 hands. The current is transmitted from the station to the works over two mains and a teaser wire at about 1,000 volts, and is reduced to about 115 volts in six 30,000-watt oil-cooled transformers, installed in a small house erected in the angle of the L-shaped main building. All the motors derive their supply of current from these transformers connected in multiple. The lightning circuits are taken off from two 7,500 and one 15,000-watt transformers. The primary wires from the station are passed through a station wattmeter just before they arrive at the transformers, and thus the consumption of energy in both lightning and motor circuits is measured in one instrument. The secondaries run from the small sub-station north and south to the motors and lights in the two legs of the L. Those running south operate in the machine shop three 20-horse-power motors, each belted to a long line of shafting, from which run 80 belts. One of these motors is used to drive 15 lathes, four shapers, and six milling machines, three water emery wheels, one planer, one die sinker, two universal grinders, two gear cutters, and two drill binders. The other two operate 35 screw machines, one oil separator, one oil pump, and two high-pressure blowers, giving air to the forges in the smithy. The feeders running north supply energy to three 30-horse-power motors, two of 10 horse-power, and two of 5 horse-power. One of the 10 horse-power motors is in the drill room, and runs a shaft from which belts run to 12 large and three small drill presses, two cone grinders, and four small milling machines. In addition it operates one band saw, one circular saw, and one wood-turner's lathe in the pattern room adjoining. The other 10 horse-power motor is in the frame-making department, and drives three large punch presses for the manufacture of handle bars, seat posts, &c., three large drill presses, four small ones, two frame assembling tables, three small milling machines, two emery grinders, one swaging machine, four stock machines, two tooth cutters, and one double polishing lathe. A large portion of the power which comes into the factory is used in the polishing room, where 35 double polishing lathes run incessantly. These are operated at present by two 30-horse-power motors. The remaining 30 horse-power motor in the north section drives a 48-inch exhaust blower, which carries away the dust from the polishing room. Electricity is also used in these factories for other purposes.

Note on Galvanic Cells.—An item of some importance has recently been contributed to our knowledge of galvanic cells by W. Ostwald and T. Mark. Last year, some of our readers who are closely interested in the subject will remember that Varet proved the identity of the heats of formation of the two mercuric oxides, and inferred that the total energies are equal for these compounds (*Comptes Rendus*, Vol. cxx., p. 620 and p. 622). A galvanic cell of mercury—red oxide—caustic potash—yellow oxide—mercury, was consequently formed by the authors, and found to give no electromotive force, whilst no changes of the electromotive force of various cells occurred when red and yellow mercury oxides replaced one another. Hence they point out that the free energy of the two forms are also equal, and that the compounds are not isomeric but identical. The paper in which this is fully described may be found in the *Zeitschrift für Physikalische Chemie*, Vol. xviii., p. 159.

Personal.—Mr. R. Woof (late of the British Thomson-Houston, Limited), has been appointed chief engineer, and Mr. P. S. Sheardoun (late of the same company) has been appointed assistant electrician to the Dublin Electric Tramway Company.

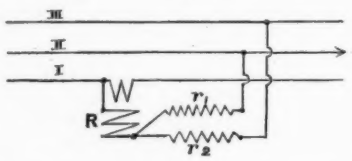
Appointment.—Mr. W. R. Wright, of Manchester, has been appointed electrical engineer to the Burnley Town Council at a salary of £200, which will probably be increased to £250 at the end of 12 months.

Electric Power Transmission.—The development of water power converted into energy by the aid of electric transmission for mining purposes is, remarks the *Engineering and Mining Journal*, steadily gaining ground. Perhaps the most noticeable in America are two three-phase mining plants and a polyphase Tesla plant, the two former being at Silverton, Colorado, and at Park City, Utah. That at Silverton is the first three-phase plant installed in the Rocky Mountain regions. It utilises water power taken from the Animas River through a 3 × 4 feet flume, 9,750 feet long. The electrical installation consists of two 150-kw. generators, driven by two double-nozzle Pelton wheels. The current, at 2,500 volts, is transmitted back up the mountains, a distance of over three miles, to an altitude of 12,300 feet above sea level, where it is used to operate various mining machinery in the Silver Lake group of mines and to drive the stamps and crushers in the mill. Previous to the installation of this electrical plant the mines were operated by steam, and the coal cost $8.75 a ton at the mine. It is calculated that an economy of $36,000 a year will be effected by the use of electricity. The Ontario mine located near Park City, in Utah, utilises the power derived from the water of the drain tunnel of the mine—the most expensive tunnel ever constructed by any mining company. It is three miles long, and discharges 1,000 cubic feet of water per minute from its mouth. This water, under a head of 120 feet, drives generators of the General Electric monocyclic type, which furnish current at 2,500 volts for transmission around the mountain to the Ontario and Daly mines, 5½ miles distant, where it drives the mills and lights the surrounding buildings. Current from these machines is also taken to light the neighbouring town of Park City. The San Miguel Gold Mining Company are so well satisfied with the result of operating in South-West Colorado, near Telluride, by long distance transmission, that they decided to largely increase their plant for themselves and neighbours, and the new plant is now being installed. This addition to the plant is supplied by the Westinghouse Company.

Further Experiments with Aluminium.—Notwithstanding the distrust which has recently been created by the results of recent experiments in Germany and elsewhere, we understand that the French War Office has recently ordered the use of aluminium drinking and mess vessels for the army. It is stipulated that these shall be beaten up from plate, and that no solder whatever shall be used in their manufacture. The event has called forth a statement from M. Balland, who recently communicated a paper to the Paris Academy of Science. He says that similar vessels to those which have been ordered for the French army vary in weight by from 4 to 9 per cent. of the total, and he attributes this to the solvent action of the soda baths which are used to clean the surface of the manufactured vessel. The vessels resist well in ordinary use, mechanical wear and tear, and the action of fire, foods, and cooking liquids which are not in contact with the metal for long periods. Water left in these vessels for some months give rise to flocculent deposits of alumina. These seem always due to particles of foreign substances in the metal, and appear especially in the neighbourhood of the rivets, which fasten the handles, and which are made of alloys of aluminium. The loss of weight in this way during six months was less than 0·1 per cent. Sheets of aluminium used in Balland's previous researches, and bottled up with Seine water for four years, became covered with a hard skin, dissolved off by 1 per cent. sulphuric acid, leaving a bright surface, and causing a loss of weight of about 3 per cent. Salt water, of 35 grms. to the litre, acted like ordinary water, but to a much greater extent. The rivets become loose, and the handles come off. Except where the nodules of alumina are, a blackish rough skin forms, which sand will not bring off, but which yields to 24 hours' soaking in 1 per cent. sulphuric acid. The loss of weight in four months, through corrosion by the salt water, was about 0·6 per cent. This communication may be found *in extenso* in the *Comptes Rendus* 121, pages 381—383.

The Institution of Electrical Engineers.—By the kind permission of Mr. Frank Bailey, a party of Students of the Institution will visit the City of London Electric Lighting Company's Bankside Central Station, on Wednesday, June 10th, at 7.30 p.m.

The Measurement of the Power of Triphased Currents.—In the *Elektrotechnische Zeitschrift* for March 19th, 1896, appears a note by Dr. Behn-Eschenburg, in which he describes a very simple method of measuring the power transmitted by the three conductors of a triphased line. It is generally known that when we are at some distance from the neutral point, or when this point is not accessible or does not exist (triangular winding), and when the charge is not equal in the three branches, the measurement of the power by the aid of an ordinary wattmeter may present some difficulties especially if there is no compensating wire. There is, however, a means of arriving quickly at the result by using an ordinary Siemens or Ganz wattmeter, or even, which is still more practical, a Siemens electro-dynamometer branched like a wattmeter. It is, however, necessary that the resistance, r, of the coil of the apparatus in derivation should be small in comparison with the non-inductive one which is to be placed in series with it. We use two equal auxiliary resistances, r_1 and r_2, placed in derivation on the movable coil and connected to two different principal conductors, the other extremity of the coil being branched on the third principal conductor as shown in the accompanying figure. The current circulating in this third conductor



passes through the fixed coil of the wattmeter. The effects of this combination are as follows:—The current passing through the movable coil is equal to the sum of the currents passing through the resistances, r_1 and r_2, which are in proportion and correspond in phase to the difference of potential between their respective conductors. The indication of the wattmeter, therefore, gives directly the measurement of the total power of the triphased currents, although the charge of the branches is unequal. In this method, we substitute the total effect for the separate effects of the two coils in derivation, which might be determined successively by two different measurements according to the old method, by using first one of the derivations and then the other.—C. B. (*L'Industrie Electrique*).

Magnetite.—Mr. W. B. Phillips, (*Eng. Mining J.*, 60, 149-150, 176, 196-197) has endeavoured to elucidate the questions as to what magnetite really is, how it may be produced, and the influence exerted by the amount of iron as protoxide upon the practical separation over a magnetic concentrator. The discussion of the chemical constitution and structural formula leads to the conclusion that magnetite ($Fe_3^{II}O_4$) is a ferrous ferrate. Analyses show remarkable variations in the ratio of $Fe\,O$ to Fe_2O_3, the extremes being 1 : 0·38 and 1 : 47·02. The protoxide of iron is stated to be non-magnetic, becoming magnetic by partial oxidation, as in the preparation of artificial magnetite from ferrous carbonate, while the sesquioxide, as is well known, becomes magnetic at high temperatures through partial deoxidation. A magnetic hydrous oxide $\{Fe(OH_2)Fe_2O_3\}$ can be formed. The proportion of partially deoxidised iron required for the efficient concentration of hæmatites is believed to be small, and a possible magnetisation of these ores by producer gas is suggested. The stability of magnetite is seen in the fact that even in an oxidising blowpipe flame it does not readily take on oxygen and lose its magnetism. A practical standard of magnetism, or means of grading ores for magnetic concentration, is regarded as an important desideratum.

The Passage of Electricity through Gases.—Experiments are described by Otho Lehmann on the electric discharge through various gases, vacuum tubes, mixed gases with different forms of electrodes, and the discharge in a strong magnetic field. The paper is illustrated by a number of figures of discharge phenomena, and the author considers the views of Goldstein and Hertz, viz., that the discharge takes place into the ether and not into the gas, to be erroneous. For further details consult *Zeit. Physikal. Chem.*, Vol. 18, pp. 97—117.

Carbon as a Resistance Material.—Herr Max Zinner ("Electro-Techniker," Vol. 14, p. 457), recommends carbon as material having many advantages as a regulating resistance for large currents. It has a higher specific resistance than any of the materials at present in use, as the annexed table will show, and a low temperature coefficient. Resistances made up of carbon rods occupy less space, and are cheaper than those made of metals or their alloys. The specific current density for carbon is very small. It amounts, for homogeneous lamp carbon of a mean diameter of 8 mm., with free access of air, to about 0·125 ampere for a final temperature increase of 100° C. :—

Metals and alloys.	Resistance in ohms of 1 m. long, and 1 mm². section, at 0° C.	Temperature coefficient for 1° C.	Ratio of the resistance to that of carbon.
Copper (annealed) ...	0·0157	0·00387	1 : 4760
Nickel	0·1240	0·0036	1 : 600
German silver ...	0·2800	0·00036	1 : 260
Nickelin	0·31 — 0·42	0·0003	1 : 240 — 1 : 170
Patent Nickel (Basse and Selve)	0·31	0·0002	1 : 240
Manganese-nickel-copper	0·45	−0·00003	1 : 160
Kruppin	0·839	0·0007	1 : 89
Manganese-copper ...	0·95	0·00004	1 : 79

Owing to the small heat conductivity of carbon, and the great emissivity, the maximum cross-section of the carbon resistance rods should not be very great. In the arrangement recommended by Zinner, round lamp carbons are mounted between two discs of slate, with suitable connections and devices for varying the resistance as required.

Steel Castings and Malleable Iron.—Prof. Benjamin writes in the "Digest" of Physical Tests, on the testing of steel and malleable iron. From the results of his tests he concludes that ordinary small purchasable steel castings have an ultimate tensile strength of 33,000 to 40,000, or an average of 37,500 lbs., and that the elastic limit may be taken at half this, the modulus of elasticity varying from 20 to 35 million. In compression, the elastic limit is 25,000 to 35,000. The removal of the scale affects the strength only according to the treatment during casting and annealing. Ordinary malleable castings gave much the same figures, and the fractures had the same appearance, an average of ten tests giving 36,160 lbs. with 1·2 per cent. elongation. In shear malleable castings gave about 43,000 lbs. resistance. There appears nothing to choose between ordinary steel castings and malleable iron. These figures are American, but it is doubtful if they would stand for English practice, where we fancy cast-steel is of better quality, and malleable iron of worse quality than American. Malleableised iron is too little known in England, and yet it can often be made of very great service. It cannot be welded unless by the electrical process, but it can be forged, and when properly made it is very reliable. The worst feature about it is its twisting and warping during the process to such an extent, as to demand a good deal of straightening.

Potential Differences between Metals and Electrolytes.—Rothmund has calculated the E.M.F. of various cells from his electro-capillary measurements of the potential differences between the metals and electrolytes composing them, and in a number of cases the values thus obtained do not agree with those directly measured. George Meyer has repeated, and in general confirmed, Rothmund's measurements. He therefore concludes that the E.M.F. of a cell, M_1, F_1, F_2, M_2, composed of the metals, M_1 and M_2, and the electrolytes, F_1 and F_2, is not given by the difference between the forces necessary to produce the maximum surface tension of polarisation of M_1 in F_1, and of M_2 in F_2. The potential difference between the two metals and two electrolytes must be taken into account, and to the difference of E.M.F. above spoken of must be added the potential difference between two dropping electrodes, which, containing M_1 and M_2, are respectively placed in the electrolytes, F_1 and F_2. It is only when this last term approaches zero in value that it can be neglected. For further details, consult *Ann. Phys. Chem.*, 1895 (2) 56, pp. 680—699.

Fly-wheel Governors.—The *Electrical World* publishes a good article on fly-wheel governors, from the pen of Mr. Geo. T. Hornchett. There are, he says, two separate actions that ought to be utilised in designing fly-wheel governors, namely, inertia and centrifugal action. These two should be made to act together. Centrifugal action comes into play when the speed of revolution is altered. Thus, if an engine slows down, the spring pulls the weight nearer in to the centre of revolution. If properly designed, the inertia of the weight should assist this action, the weight moving forward relatively to the wheel. In so doing, it should aid the centrifugally created movement. It would appear as though these two actions had rarely been considered by designers. Some governors have them in opposition to one another, and the tendency is to cause hunting; others have them properly combined, but whether by accident or design does not appear. In some governors the inertia pull comes direct upon the pins, and cannot possibly have any effect on the valve motion. In others, it is allowed by accident or design to have such an effect, and some mathematical discussions of the question have so obviously overlooked the double action when present, as to render the discussion quite valueless. There are four actions to be considered in a fly-wheel governor:—1. The centrifugal force, which is constant when the speed is constant, and the position of parts unchanged. 2. The spring tension, constant when the position of parts is unchanged. 3. The inertia action, present only when the speed is in process of changing. 4. The pull of the valve rod on the mechanism, which is variable and incalculable. This last factor requires elimination as far as possible, and the governor should be so arranged that when the valve rod is being moved the pull comes on some rigid pin, and where the valve is at positions of comparative rest, the governor mechanism is passing a position where the pull would have most effect. Hence by increasing the weight of the governor, and expending some care on the above point, the valve rod pull may be reduced to a nearly negligible degree. The position assumed by the weight, and due to inertia action, is dependent upon the position of the pivot of the weight arm inside or outside the tangent to the circle of rotation of the weight. If directly on the tangent, then inertia action is all absorbed on the pivot, and the advantage of inertia is lost. The spring pull and the centrifugal force should nearly balance each other, but the spring pull should increase faster at an accelerating rate, which can be secured by placing it at an angle with the weight arm in such a way that as the weight moves out, the spring approaches to a line at right angles with the arm. This gives stability, and by this device a spiral spring may be made to give any counterbalancing action that may be desired within a wide range.

The X Rays and Temperance.—An American exchange says:—"Hope springs eternal in the breast of Frances Willard, whose devotion to the cause of temperance, coupled with a sanguine nature, sometimes leads her to embark on a rainbow-chasing expedition. 'I believe the X rays are going to do much for the temperance cause,' says Miss Willard. 'By this means drunkards and cigarette smokers can be shown the steady deterioration in their systems which follows the practice, and seeing is believing.' . . . . The victims cannot be cured simply by inviting them to look at inside and out views of others who have preceded them on the downward path. Miss Willard is wrong in thinking that intemperance is due in any considerable degree to lack of knowledge of its evil effects; and even if she were right in this particular, it would be difficult to see how the X rays could add greatly to that knowledge."

Battery Charging Extraordinary. — Some unkind friend has been hoaxing the *Independance Belge* on the subject of the alleged charging of an accumulator from the tramway track on the Boulevard du Regent. Our contemporary states that three young men, desiring to charge an accumulator, connected one lead to one of the rails, and threw the other over the trolley wire; and that the charging was accomplished. If this is not another case of Brussels sprouts, what is? We shall next hear of the owner of the accumulator bringing an action against the tramway company for assault and battery, for the spinal column of that accumulator must have suffered severely from the attack of 500 volts, even if the three young men escaped scot free.

A C.B. on Education.—The following cutting from the *Referee* of last Sunday is too good to be lost to science, so we reproduce the words of wisdom of the youngest F.R.S.E. and C.B. in England, filtered through the omniscient mind of the "Handbooker":—"I almost despair of catching up my arrears in the matter of topics. In the brief space still left me let me return to the subject of education, in order to give the gist of an interesting communication from Mr. Charles Bright, the eminent civil engineer, who has been taken by my suggestion that there ought to be a sort of examination for worldly success in addition to, or in substitution of, the more technical tests now in favour. Mr. Bright thinks that in connection with such an 'exam.' —and I cordially agree with him—there ought to be a doctor's certificate regarding the candidate's digestion, for, after all, permanent ability for work, where any thinking has to be done, must greatly depend on physical fitness. Then, unquestionably, an important factor in the attainment of worldly success is, that the candidate should be working in a congenial groove, that he should take up the pursuit to which his character is best adapted. As to this, my correspondent observes:—'Inasmuch as very few parents are sufficiently observant, or sufficiently good judges of character, to see what their children are best fitted for, it would seem as though there were plenty of scope for professional parents, so to speak. There is no doubt about it! It would be well if head masters and house masters of public schools were men of the world (retired admirals and generals, for instance), rather than mere scholastics, who have taken a double-first in classics. They would study the boys individually, and not treat them all as of one brand, the teaching in classes being left to assistant-masters, who might be senior wranglers, double-firsts, or anything else, though I very much doubt whether the man who knows the most can teach the best.' Probably most boys of special aptitude do ultimately drift into the occupation to which they are best suited, but such a system as that above indicated could not fail, I think, to be of advantage. The great obstacle, I daresay, would be the narrowmindedness of the parents, who often take it into their heads that their sons must go into this or that profession, possibly for some snobbish reason, and certainly without any thought as to the boy's fitness. There is still too prevalent an impression that all boys are born pretty much alike, and that it is the cowl that makes the monk. A great mistake!"

Strength of Steel Rails.—The President of the Board of Trade has appointed a committee, consisting of the following gentlemen, viz.:—Lord Blythswood (chairman), Sir Benjamin Baker, K.C.M.G., F.R.S.; Sir J. Lowthian Bell, Bart., F.R.S.; Professor Wyndham Dunstan, F.R.S.; Professor A. B. W. Kennedy, F.R.S.; Major F. A. Marindin, R.E., C.M.G.; Mr. E. P. Martin; Professor W. C. Roberts-Austen, C.B., F.R.S.; Dr. T. E. Thorpe, F.R.S.; Professor W. C. Unwin, F.R.S.; and Mr. E. Windsor Richards, to inquire as to the extent or loss of strength in steel rails produced by their prolonged use on railways under varying conditions, and what steps can be taken to prevent the risk of accidents arising through such loss of strength. Mr. W. Marwood, of the Board of Trade, has been appointed to act as secretary to the committee.

An Incomplete History.—Mr. Francis B. Crocker attempts to write "The History of Electric Lighting" in a few columns of the *Electrical World;* one can hardly expect, therefore, that the history will be complete, but it might have been more accurate in a few details. The author, commencing at the 17th century, traces the work of the various pioneers down to the present date. There are errors in the spelling of the names of prominent men, but what we notice more particularly is the entire absence from this history of the name of Werdermann, who did so much with the semi-incandescent lamp. Other names occur to us which ought also to have had a place.

Royal Institution.—To-night, at nine o'clock, Professor J. A. Fleming will lecture on "Electric and Magnetic Research at Low Temperatures." On 19th inst. Mr. T. Commerford Martin, of New York, American delegate to the Kelvin celebration, will deliver a discourse (with illustrations) on the "Utilisation of Niagara."

The Mobility of Molecules of Cast-Iron.—Mr. A. E. Onterbride, jun., states in the *Digest of Physical Tests*, that cast-iron is materially strengthened if subject to shock or blows within limits, a fact he positively affirms, though so contrary to general belief. In annealing a casting, the strength is increased by the release of certain self-imposed stresses, due to unequal cooling and contraction; but he now states that the molecules will move without the annealing process, and will re-arrange themselves, or, in other words, annealing may be accomplished at ordinary temperatures. He noticed in 1883 that chilled car wheels rarely cracked on ordinary service, unless comparatively new. This fact, however, is merely negative, the cracking of the new wheels may be claimed to eliminate the weaker vessels, and those which survive are the better ones, and not likely to crack, of course, if they get over the early service. In 1894 a lot of test bars, knocked about for several hours in a tumbling barrel, showed a higher average than usual with similar mixtures. This caused inquiry, and a set of 12 bars was made, six being cleaned by wire brush, and six in the tumbling barrel for four hours. These latter were stronger by 10 to 15 per cent. than the others, the metal being soft foundry iron, and these tests were repeated with similar results on several consecutive days, and explanations sought. Was it due to the rounding of the corners? No, because when the untumbled bars had their corners filed down, no gain was observed. Round bars were next made, and again the tumbled bars were the stronger. This was followed by subjecting six test bars to 3,000 taps on end from a hand hammer, and the same gain of strength accrued as with the tumbled bars. As might be expected, hard or strong irons show greater gain than softer irons, and larger bars show a greater proportionate gain than small bars. Impact experiments were then made. Six bars were broken by falling weight, sufficient to break the bars at one blow; six companion bars were then subjected to 10 to 50 blows of the same weight falling half the distance, the blows being insufficient to break the bars. Then the drop was given which had broken at once all the first six bars, and not one of the second set now broke. Two, three, six, 10, and even 15 of the maximum blows were needed. These are results of a long series of tests at Messrs. W. Sellers & Co.'s works, and the deductions to be drawn are that cast-iron for heavy stresses should be gradually inured to its work, not put at once to maximum duty. Old castings are, when they have not been misused, really stronger than new ones. In testing a new gun, for example, the first few rounds, if light, would enable the gun to shake itself free of initial stresses, and so become much stronger. The subject is full of interest, and there appears no reason to doubt that the true explanation has been found of the marked increase of strength of tumbled or imported bars. The maximum gain noted was 19 per cent. It has been the fashion to ascribe the strength and toughness of old castings to cold blast iron. Is it not possible that something may be due to vibration annealing? If so, the value of the "tough old metal" will tend downwards, for if not a material quality, the strength would not survive remelting. Of course, all the blows are well within the limit of instant rupture.

Researches on Tartrates.—Louis Kahlenberg has been investigating some of the complex tartrates, for example, the lead potassium and copper potassium double tartrates, and in doing this he has made an interesting use of electrical facts and methods. By the determination of the E.M.F of a lead/lead acetate/lead potassium tartrate/lead cell, he was able to determine the concentration of the lead ions in the tartrate as 10^{-74}, and to infer that therefore only a mere trace of lead can exist in the ion state in this salt. He was also able to infer an interesting chemical deduction concerning the molecular constitution of these substances by determining the concentration of the hydroscyl ions, using as an electrode manganese dioxide.

X Rays.—A Berlin telegram says that the General Electrical Association of that city have succeeded in rendering it possible for the internal structure of the head, the larynx, and more especially the action of the respiratory organs and heart, to be observed direct on the fluorescent screen. A practical demonstration is to be given at the Surgical Congress.

The Colour of the Ions.—A few months ago we had occasion to notice an important paper by M. Carey Lea *American Journal of Science*, xlix., p. 357, on the colour of the atoms, ions, and molecules, in which he arranged the elements in a periodic system on the basis of the colour of the ions as determined by his researches. Julius Thomsen has now published another paper on the same subject in the *Zeitschrift für Anorganische Chemie*, x., p. 155. He is by no means new to this department of research, for in 1892, in the *Zeitschrift* (ix., p. 192), he published a periodic system, which at the time attracted considerable attention. He now points out that that form of periodic system is in accordance with a very simple relation between the colour of the ions and the atomic weights! those ions only are coloured which belong to the middle members of the large series. The two first series, with seven members, contain no coloured ions; the two next, with 17 members, contain in each series seven to eight coloured ions (titanium to copper, and niobium to silver), and in the fifth series, with 31 members, the group with coloured ions (cerium to gold) is in the middle of the series.

The Institution of Electrical Engineers.—There was a very small attendance at the special general meeting called on Friday last to consider the proposed alterations in the articles of association. Dr. Hopkinson gave a general explanation as to the effect of the proposed modifications of the articles, and the reasons that led to their proposition. He said the Council had considered each of the suggestions that had been made from outside upon its merits, and that the proposed modified articles was the outcome of their deliberations. He then went through each of the articles *seriatim*, and after a few alterations had been made, the whole of the modified articles, as amended, were put to the meeting and carried unanimously. Thereupon Major Flood Page proposed a vote of thanks to Dr. Hopkinson, and to the Council, for the way in which they had met the suggestion proposed from outside the Council. This was seconded by Mr. Raworth, and carried unanimously, after which the meeting dispersed.

Lord Kelvin's Jubilee Celebrations.— Programme of the celebration proceedings of the jubilee of Lord Kelvin as Professor of Natural Philosophy at Glasgow University: On Monday, June 15th, at 8.30 p.m., there will be a conversazione, with an exhibit of Lord Kelvin's inventions. On Tuesday, June 16th, addresses will be presented to Lord Kelvin by delegates from home and foreign University bodies, from Societies, and others. On Tuesday evening, June 16th, a banquet will be given to Lord Kelvin. On Wednesday, June 17th, the Senate of the Glasgow University will invite the visitors of the University staff to sail down the Clyde. The students of the University also invite the students' delegates from other Universities to a similar trip. We understand from *Nature* that representative scientific men —about 50 in number—from America and the British Colonies, and from all the European countries, and about 150 from the United Kingdom, have signified their intention to be present.

The Institution of Civil Engineers.—At the annual general meeting on Tuesday, the following Council was elected for the ensuing year:—President, John Wolfe Barry, C.B.; Vice-Presidents, William Henry Preece, C.B., Sir Douglas Fox, James Mansergh, and Dr. William Anderson, C.B. Other Members of Council: Alexander Richardson Binnie, Henry Deane (residing in Australia), William Robert Galbraith, George Graham, James Henry Greathead, J. C. Hawkshaw, Charles Hawksley, Dr. John Hopkinson, Dr. Alexander Blackie, William Kennedy, John Kennedy (Canada), George Fosbery Lyster, Sir Guilford Molesworth, K.C.I.E., Captain Sir Andrew Noble, K.C.B., William Shelford, Dr. Bindon Blood Stoney, Francis William Webb, Sir William White, K.C.B., and Sir Edward Leader Williams.

Erratum.—In the note on "A New Electrolyser" in our last issue the word *ozone* in line 8 should read *zone*.

Accident Due to Gas.—At Soho Hill, Handsworth, the other day, a gas explosion occurred, doing considerable damage.

NEW COMPANIES REGISTERED.

Anti-Vibration Incandescent Lighting Company, Limited (48,065).—This company was registered on May 23rd with a capital of £5,400 in £10 shares, to acquire certain British, foreign, and colonial patents relative to incandescent gas lamps, to acquire and take over as a going concern the business of gas engineers, carried on at Bradford, Yorkshire, as "The Incandescent Gas Lighting Improvement Company," and to carry on the business of a gas and electric lighting company. The subscribers (with one share each) are:—T. Redman, Rose Mount, Bradford, gas engineer; F. E. Nichol, Paper Mills, Portobello, clerk; W. Andrews, 66, Oakleigh Road, Clapton, salesman; F. H. Bentham, 7, Spring Place, Bradford, manufacturer; G. H. Firth, 26, Eldon Place, Halifax, engineer; F. Foster, 3, Spring Place, Halifax, wool merchant; J. D. Mander, 90, Boynton Street, Bradford, cashier. The number of directors is not to be less than three nor more than seven; the subscribers are to appoint the first; qualification, £100; remuneration as the company may decide. Registered by Waterlow & Sons, Limited, London Wall, E.C.

Electrical Copper Company, Limited (48,068).—This company was registered on May 23rd with a capital of £500,000 in £1 shares (150,000 preference), to adopt an agreement dated April 8th, and made between E. Dumoulin of the one part, and R. M. Moir and Co. (for the company) of the other part, and to acquire, develop, turn to account, work and deal with certain patents, patent rights and inventions relating to the manufacture or treatment of copper and other metals by electrolysis. The subscribers (with one share each) are:—H. M. Matheson, 3, Lombard Street, E.C., merchant; C. A. Fould, 85, Avenue Morceau, Paris, deputé; E. Dumoulin, 19, Rue Miromesnil, Paris, proprietaire; A. McKechnie, Ditton Road, Widnes, smelter; R. M. Moir, 1, St. Swithin's Lane, E.C., merchant; R. Lorimer, 1, St. Swithin's Lane, E.C., merchant; L. S. Johnson, 197, Dalston Lane, N.E., clerk. The number of directors is not to be less than five nor more than nine. The first are—H. M. Matheson, A. Fould, W. Jacks, A. McKechnie, R. M. Moir and E. Dumoulin. Qualification £400; remuneration £2,000 per annum, and a share in the profits, divisible. Registered office, 1, St. Swithin's Lane, E.C.

Malaga Electricity Company, Limited (48,076).—This company was registered on May 23rd, with a capital of £57,000, in 10,000 ordinary shares of £5, and 7,000 deferred shares of £1 each, to adopt an agreement with Zulueta and Co., and to carry on the business of electricians, suppliers of electricity, manufacturers of electrical apparatus, engineers, iron and metal founders at Malaga, Spain, or elsewhere. The subscribers are:—J. M. de Zulueta, 41, Moorgate Street, E.C., merchant, 1,900 shares; R. C. Wyatt, 41, Moorgate Street, E.C., merchant, 100 shares; A. Hill, 5, Tokenhouse Yard, stock dealer, 1,000 shares; F. S. Isaac, 22, Great Winchester Street, E.C., merchant, 1,000 shares; A. Fowler, 6, Lombard Street, E.C., engineer, 1,250 shares; L. Floersham, 4, Bank Buildings, E.C., merchant, 1,000 shares; T. W. Bernard, Malaga, Spain, merchant, 400 shares. The number of directors is not to be less than three nor more than four; qualification 50 shares; maximum £800 per annum divisible. Registered by Ashurst and Co., 17, Throgmorton Avenue, E.C.

Queen Anne Residential Mansions and Hotel Company, Limited (48,103).—This company was registered on May 27th with a capital of £250,000, in £5 shares, to acquire the Queen Anne Mansions and other property adjoining the Broadway, Westminster, and the business of the Queen Anne and Garden Mansions Company, Limited, and the Queen Anne Mansions Electric Lighting and Heating Company, Limited, to adopt an agreement with H. Bennett, and to carry on the business of land and property owners and agents, hotel proprietors, electricians, and suppliers of electricity, water and power. The subscribers (with one share each) are:—H. Bennett, 175, Sloane Street, S.W., auctioneer; H. I. W. Holt, 12, Great Marlborough Street, W., solicitor; C. S. Pemberton, 44, Lincoln's Inn Fields, W.C., solicitor; F. E. J. Smith, 2, Tanfield Court, Temple, solicitor; F. Harman, 57, Weymouth Street, W., solicitor; C. Marchant, 10, Duke Street, St. James's, solicitor; H. Royle, 175, Sloane Street, S.W., gentleman. The number of directors is not to be less than three, nor more than nine. Qualification £250; remuneration £250 each per annum. Registered by Leed Pembertons, 44, Lincoln's Inn Fields, W.C.

Simplex Electric Tramway Conduit Syndicate, Limited (48,119).—This company was registered on May 29th with a capital of £30,000, in £1 shares, to acquire from J. B. Atherton a certain invention for improvements in the means of, and appliances for, distributing and collecting electricity for the propulsion of vehicles, to adopt an agreement with the said inventor, and to own and work tramways, railways, &c. The subscribers (with one share each) are: T. Snape, J.P., The Gables, Croxteth Road, Liverpool; A. Adam, Steeton Hall, near Keighley, barrister; J. B. Atherton, Manhattan, Rainhill, manufacturer; J. Atherton, Mayfield, Huyton, manufacturer; R. Watson, Newfield, Johnston, paper maker; J. Monkhouse, 16, Hertford Drive, Liscard, cashier; R. Sumner, 38, Osborne Road, Anfield, Liverpool, clerk; A. Wilkinson, 227, Whitefield Road, Everton, book-keeper. The number of directors is not to be less than three, nor more than seven; remuneration, £150 each per annum. Registered by T. T. Hull, 22, Chancery Lane, W.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Eastern Extension, Australasian and China Telegraph Company, Limited (7,224).—This company's annual return was filed on May 21st. 250,000 shares have been taken up out of the capital of £3,000,000, in £10 shares, and the full amount has been called and paid.

Edison-Gower-Bell Telephone Company of Europe, Limited (16,010).—This company's annual return was filed on April 13th. 385,009 shares have been taken up out of a capital of £500,000, in £1 shares, and 370,000 of these are considered as fully paid. The full amount has been called on the rest, £15,005 has been paid, and £4 is outstanding.

Scottish House-to-House Electricity Company, Limited (29,232).—This company's annual return was filed on May 21st. The capital is £100,000 in £5 shares (of which 100 are founders'); 730 ordinary and all the founders' have been taken up and the full amount called; £4,258 has been paid, and £162 is in arrears; £108 has been paid on 54 shares forfeited.

County of London and Brush Provincial Electric Lighting Company, Limited (34,320).—This company's annual return was filed on May 21st. The capital is £800,000 in 40,000 preference and 40,000 ordinary shares of £10 each; 10,000 preference and 22,475 ordinary have been taken up, and the full amount has been called; £324,346 has been paid, and £404 is in arrears.

Edison-Bell Phonograph Corporation, Limited (37,655).—This company's annual return was filed on April 21st. The whole capital of £60,000 in £10 shares has been taken up, and 4,000 shares have been considered as fully paid. The full amount has been called on the rest, and £40,000 has been paid.

Saxby and Farmer, Limited (38,786).—This company's annual return was filed on May 15th. Out of a capital of £25,000, in £10 shares, 2,021 shares have been taken up, and of these 1,800 are considered as paid. £10 per share has been called on the rest, and £2,210 has been received.

CITY NOTES.

Portsmouth Accounts.

The annual balance-sheet, made up to March 31st, 1896, is of a satisfactory and encouraging character. On March 31st, 1895, the capital expended was £56,385; during the year, £34,871 fresh capital, has been raised, making a total of £91,256. Of this sum, £86,998 14s. 5d. has been expended on buildings, machinery and plant, mains, cables, &c., leaving a balance of £4,257 5s. 7d. Turning to the revenue account, the progress during the last three months of the financial year was considerable. In conformity with the Board of Trade regulations, a balance-sheet is made up for the year ending December 31st, whereas for municipal purposes the balance-sheet is made up to March 31st. For the year ended December 31st the figures were:—Revenue, £6,533 8s. 8d.; expenses, £4,069 14s. 2d.; gross profit, £2,463 14s. 6d.; year ended March 31st, 1896, £7,387 13s. 1d.; expenses, £4,010 10s. 9d.; gross profit, £3,377 2s. 4d. Of the latter sum, the Electric Lighting Committee reserve £47 2s. 4d. as provision for bad debts, and carry forward £3,300 towards the account of interest on redeemable stock and mortgage debt and the loans fund account for redemption of capital. These two accounts absorb £3,749 5s. 5d., thereby showing that during the whole 12 months, after all current expenses, interest on capital, and redemption of loan have been paid, the net deficit is only £419 5s. 5d.

The cost of production, which is given below, is very creditable to Mr. Price, and the exceedingly little loss on the system is especially noteworthy; indeed, the works in this country that can show so small a loss as 6 per cent. are few.

The following table gives the cost per unit:—

	1893.	1894.	1895.*
Total capital expended ...	—	—	£91,256
Number of units sold	—	—	406,118
Quantity generated in B.T. units	—	—	466,484
Quantity accounted for ...	—	—	437,094
Percentage loss	—	—	6
Number of lamps connected ...	—	—	—
Revenue from sale of current...	—	—	£7,000
Net revenue	—	—	£3,330
Average price obtained per unit	—	—	4·1d.

* Accounts made up to March 31st, 1896.

Cost of Production.	£	s.	d.	Per unit.
Coal	1,139	0	0	·67d.
Oil, waste, water, and engine room stores	268	0	0	·16d.
Salaries and wages at generating station	684	0	0	·40d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	487	0	0 (Works' cost 1·51d.)	28d.
Rates and taxes	193	0	0	·11d.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges, and insurance	733	0	0	·43d.
Depreciation of buildings and plant account	—			—
Renewal fund account	—			—
Total	£3,504	0	0	2·05d.

Revenue.	£	s.	d.	Average price obtained per unit.
By sale of current	7,000	0	0	4·1d.
Meter rents, &c.	145	0	0	—
Sale of lamps	212	0	0	—
Total	£7,357	0	0	4·1d.

Total cost per unit (exclusive of depreciation and renewal accounts), 2·05d.; works' cost, 1·51d.

The Nelson Accounts.

Although the Nelson Corporation Electricity Works have reached their third year of working, the abstract from the sheet that is before us is the first that has been published. There is no question about the results being excellent, the cost of coal reaching the exceptionally low figure of ·37d. We have not received a full balance-sheet, but we gather from the information that has been sent that after paying interest on loans, £323 15s. 11d., and making a contribution of £249 18s. 8d. to sinking fund, the undertaking is able to hand over for the relief of rates the sum of £255 19s. 6d., which must be gratifying to the Corporation. As municipal bodies, owning both gas and electricity works, have been somewhat prone to stifle the natural development of the electrical undertaking, it is very refreshing to note the progress that has been made by the Nelson Electricity Works. Mr. J. Foster, who is the engineer both at the gas and electricity works, is to be congratulated on achieving such excellent results.

The following table gives the cost per unit:—

	1893.	1894.	1895.
Total capital invested	—	—	£9,958
Number of units sold	—	—	64,981
Number of lamps connected	—	—	4,500
Revenue from sale of current	—	—	£1,281
Net revenue	—	—	—
Average price obtained per unit	—	—	4·62d.

Cost of production.	£	s.	d.	Per unit.
Coal	101	0	0	·37d.
Oil, waste, water, and engine room stores	7	0	0	·03d.
Salaries and wages at generating station	221	0	0	·82d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	20	0	0 (Works' cost 1·29d.)	·07d.
Rates and taxes	24	0	0	·09d.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges, and insurance	78	0	0	·29d.
Depreciation of buildings and plant account	—			—
Renewal fund account	—			—
Total	451	0	0	1·67d.

Revenue.	£	s.	d.	Average price obtained per unit.
By sale of current	1,251	0	0	4·62d.
Meter rents	29	0	0	—
Sundry sales	—			—
Total	£1,280	0	0	4·62d.

Total cost per unit (exclusive of depreciation and renewal accounts), 1·67d.; works' cost, 1·29d.

Electric Traction Company, Limited.

The report of the directors of the Electric Traction Company, Limited, for 1895, to be submitted on Friday next to the general meeting, states that the allotment of the company's share capital took place on June 18th, 1895, and the whole of it has been subscribed. The deferred shares are fully paid, and £2 per share has been paid on the ordinary shares. On June 18th, 1895, the company entered into a contract with the Central London Railway Company for the acquisition of the necessary land and the construction and equipment of the railway with all its appurtenances, to the satisfaction of the railway company's engineers. Immediately after the execution of the above contract, this company proceeded with the compulsory acquisition of the properties required for the station sites and the generating depôt at Shepherd's Bush, with the result that thus far upwards of three-fourths of the total number of claims have been settled or adjudicated upon. This work is being pushed forward as quickly as possible, so that possession of station sites may be obtained to enable the work of construction to be commenced not later than July 1st next. The line from Shepherd's Bush to the Bank has been divided into six sections, and on February 19th last a selected number of firms were invited to tender for the construction of the tunnels and shafts, and incidental work. A considerable number of tenders having been received, the directors have entered into the following sub-contracts:—Sections 1, 2 and 3, Shepherd's Bush to Marble Arch, Mr. J. Price; sections 4 and 5, Marble Arch to Post Office, Messrs. Walter Scott & Co.; section 6, Post Office to Bank, Mr. G. Talbot. The arrangements with regard to the station at Liverpool Street are progressing satisfactorily. The prices at which these sub-contracts—which cover the principal part of the work of construction—have been let, and the cost of acquiring the station sites are fairly in accord with the estimate formed as to the cost of the undertaking, and confirm the directors' anticipation that the construction and equipment of the Central London Railway will be carried out within the contract price, with a fair margin of profit to this company.

The West African Telegraph Company, Limited.

The report and accounts of the directors for the year ended December 31st, 1895, to be presented to the eleventh ordinary general meeting, to be held at Winchester House, 50, Old Broad Street, London, E.C., on June 11th, 1896, at 12.15 p.m., states that the directors submit the accounts and balance-sheet of the company for the 12 months ended December 31st, 1895. The company's revenue for that period amounted to £74,333 4s. 9d., against which £17,474 10s. 2d. is charged for ordinary expenses, and £6,298 1s. 10d. for expenditure relating to repairs of cables, &c. After providing £875 13s. 11d. for income-tax, and £24 16s. 8d. due to re-valuation of currency assets, there remains a balance of £49,660 2s. 2d. From this balance there has been deducted £11,322 17s. 10d. for interest on debentures, and £12,333 6s. 8d. for sinking fund, leaving £26,003 17s. 8d., out of which the directors have placed £15,000 to the general reserve fund. The shareholders have received for the six months ended June 30th, 1895, an interim payment of 2s. per share, and the directors now recommend a final dividend of 6s. per share, making 4 per cent., free of income-tax, for the year ended December 31st, 1895. The balance of £1,760 5s. 8d., shown at the foot of the revenue account, is proposed to be carried forward to next year. The director who retires by rotation is Sir Henry C. Mance, C.I.E., who, being eligible, offers himself for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., also retire, and offer themselves for re-election.

The Electric and General Investment Company, Limited.—The directors have decided, subject to the completion of the audit, to recommend to the shareholders the payment of a further dividend upon the ordinary shares at the rate of 30 per cent. per annum for the six months ended May 31st last, making, with the interim dividend at the rate of 10 per cent. per annum already paid, a total dividend of 20 per cent. for the year, and also to recommend a dividend of £20 on each founders' share for the year. The trustees for the founders' shares reserve fund propose to distribute to the holders of such shares a sum of £20 per share for the year out of the proceeds of investments sold and dividends received in respect of the founders' reserve fund, making, with the before-mentioned dividend, a total distribution of £40 on each founders' share. The dividends, &c., to be payable on the 19th inst.

Crompton & Co., Limited.—We learn that Mr. John Trotter (of Messrs. John Trotter & Co.), who is a director of the Commercial Union Assurance Company, Limited, and the chairman of the Mitcham Linoleum and Floorcloth Company, Limited, has joined the board of Crompton & Co., Limited, and has been elected chairman of the company in the place of Viscount Emlyn, resigned.

Electric and General Investment Company, Limited.—The transfer books and register of members will be closed from June 5th to June 18th for the purpose of preparing dividend warrants.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending May 31st, 1896, were £842; week ending June 2nd, 1895, £929; decrease, £87; total receipts for half-year, 1896, £20,535; corresponding period, 1895 £20,533; increase, £2.

The Direct Spanish Telegraph Company. The estimated receipts for the month of May, 1896, were £2,396.

The Liverpool Overhead Railway Company. The receipts for the week ending May 31st, 1896, amounted to £1,809; corresponding week last year, £1,146; increase, £663.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 29th, 1896, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,590.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation, May 27th.	Closing Quotation June 3rd.	Business done during week ended June 3rd, 1896. Highest.	Lowest
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	4 %	4 %	4 %	100 —104	100 —104	...	...
25,000	Amazon Telegraph, Limited, shares...	10	...	...	...	10 — 11	10 — 11	10	...
1,012,880£	Anglo-American Teleg., Ltd.	Stock	£2 11s.	£2 2s.	£2 9s.	48 — 50	48 — 50	48½	48¼
2,993,560£	Do. do. 6 % Pref.	Stock	£5 2s.	£4 4s.	£4 18s.	91½— 92½	92 — 93	92⅞	91⅝
2,993,560£	Do. do. Defd.	Stock	...	...	...	9 — 9½	8⅞— 9½	9⅛	...
130,000	Brazilian Submarine Teleg., Ltd.	10	6½% §	7 %	...	15 — 15½	15 — 15½	15⅝	15½
75,000£	Do. do. 5 %, Debs., 2nd series, 1906	100	5 %	5 %	...	113 —117	113 —117	114½	114
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	... §	2½%	...	3 — 3½	3 — 3½	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	160 —170	160 —170	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 % §	1½%	...	3/16— 3/16	3/16— 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12 — 13	12 — 13	12⅝	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	19½— 20½	19½— 20½	...	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	4 — 5	4 — 5	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 10½	10 — 10½	...	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000 ...	50	...	4½%	4½%	106 —109 %	106 —109 %	...	...
60,710	Direct United States Cable, Ltd.	20	2⅝% §	2 %	...	9⅛— 10	9½— 10	...	...
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½%	...	17 — 17½	17 — 17½	17⅝	17 1/16
70,000	Do. 6 % Cum. Pref.	10	6 % §	6 %	...	18½— 18⅝	18 1/16— 18⅝	18 3/16	18
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	...	106 —109	106 —109	...	...
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	...	130 —133	130 —133	133	132½
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	17⅝— 18¼	17½— 18	17 15/16	17⅝
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5 %	101 —105	101 —105	102	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5 %	102 —105	102 —105	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4 %	131 —134	131 —134	134	132½
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5 %	101 —105	101 —105	...	...
107,600£	Do. do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5 %	102 —105	102 —105	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4 %	105 —108	105 —108	107½	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4 %	110 —113 %	110 —113 %	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4⅜% §	4½%	...	10⅛— 11	10½— 11	10 1/16	10 1/16
180,042	Do. do. 6 % Pref.	10	6 % §	6 %	...	17 — 17½	17 — 17½	17 5/16	17⅛
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜%	8⅜%	10 %	23 — 24	23 — 24	24	...
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	104 —107	104 —107	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	52 — 55	52 — 55	54	53
100,000£	London Platino-Brazilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6 %	109 —112	109 —112	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000... ...	5	4 %	4 %	...	2 — 2½	2 — 2½	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 % §	5 %	5⅛%	7¼— 7½	7⅛— 7⅞	7⅞	7 7/16
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	16 — 18	16 — 18	18	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	16½— 17½	16½— 17½	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6⅝— 6⅞	6⅝— 6⅞	6⅞	...
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	107 —110	107 —110	109½	108½
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	4½%	5 %	9/16— 11/16	9/16— 11/16	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	108 —111	108 — 111	...	...
11,839	Reuter's Ltd.	8	0 %	*nil*	5 %	6½— 7½	6½— 7½	6⅝	...
3,381	Submarine Cables Trust	Cert.	...	...	...	135 —140	135 —140	...	...
58,000	United River Plate Teleph., Ltd.	5	...	3 %	...	3½— 4	3½— 4	...	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	...	99 —104	100 —105	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	*nil*	*nil*	4 %	7½— 8½	7½— 8½	...	...
238,300£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	103 —106	103 —106	...	...
30,000	West Coast of America Teleg., Ltd.	10	*nil*	*nil*	*nil*	1 — 2	1 — 2	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	8 %	99 — 104	100 —105	103	...
64,248	Western and Brazilian Teleg., Ltd.	15	2½%	3 %	3 %	9½— 9⅞	9 — 9¼xd	9⅜	9⅛
33,129	Do. do. do. 5 % Pref. Ord. ...	7½	5 %	5 %	5 %	6¾— 7½	6⅞— 7½xd	7 5/16	6⅞
33,129	Do. do. do. Def. Ord.... ...	7½	...	1 %	1 %	2½— 3	2½— 3 xd	...	...
165,200£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	6 %	104 —108	104 —108	...	...
206,400£	Do. do. do. do "B," do.	100	6 %	6 %	6 %	104 —108	104 —108	...	...
88,321	West India and Panama Teleg., Ltd.	10	⅞%	⅞%	⅞%	1⅛— 1⅜	1 — 1⅛xd	1⅛	1⅛
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	11½— 11⅝	11 — 11½xd	11⅝	...
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	9½— 10½	9½— 10½xd	...	...
80,000£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	5 %	108 —111	108 —111	110½	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7 %	110 —115	110 —115	...	...
164,300£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	102 —105	102 —105	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	4½%	4½%	5 %	8¼— 8⅜	8¼— 8⅜	8½	...
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	5 %	5 %	5 %	7½— 8	7½— 8	...	...
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	...	4 %	116 —119	116 —119	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	5 %	5 %	14½— 15½	14½— 15½	15½	15 5/16
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	16½— 17	16½— 17	16 13/16	16¾
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	134 —138	134 —138	...	...
22,475	County of London and Brush Prov. Elec. Ligtg., Ltd., Ord. 1—22,475	10	...	...	*nil*	8½— 9½	8½— 9½	...	...
10,000	Do. do. do. 6% Pref., £8 pd., 40,001—50,000	10	...	...	6 %	12½— 13½	12½— 13½	13¼	12 13/16
50,000	†Liverpool Electric Supply, all paid	5	5 %	5½%	6 %	8 — 8½	8 — 8½	...	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	2½%	3 %	4 %	14 — 15	13½— 14½	14 1/16	14
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	4½%	120 —123	120 —123	122	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	1 %	2 %	9 — 9½	9 — 9½	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	4½%	6½%	7½%	10½— 11	10⅝— 11½	11	10 13/16
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	10 — 11	10 — 11	11	10½
67,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	4 %	5 %	7 %	9½— 10	9½— 10	9⅞	9½

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation, May 27th.	Closing Quotation, June 3rd.	Business done during week ended June 3rd, 1896. Highest.	Lowest
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	5 %	2½%	...	1½ — 1⅝	1½ — 1⅝	...	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 %	3 %	...	1⅝ — 1⅞	1⅝ — 1⅞	...	...
125,000£	Do. do. 4½ % Perp. Deb. Stock.	Stock	4½%	4½%	...	111 —114	111 —114	...	...
630,000£	City and South London Railway	Stock	1¹⁄₁₆%	1¼%	1⁵⁄₁₆%	42 — 44	42 — 44	43	42
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	3 %	*nil*	...	2 — 2½	2 — 2½	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	7 %	5 %	...	1½ — 1⅝	1½ — 1⅝	...	...
17,139	Do. do. do. "A" Shares 01—017,139	5	7 %	5 %	...	2½ — 3½	2½ — 3½	...	...
100,000	Do. do. do. 4½% Deb. Stock Red. ...	Stock	...	4½%	...	104 —107	104 —107	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	*nil*	...	1½ — 1⅝	1 — 1½	1½	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	...	2½ — 3	2½ — 3	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	⅝ — ⅞	½ — ¾	...	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	½ — ⅝	⅝ — ⅞	...	...
9,600£	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	*nil*	*nil*	...	9½ — 10½	10½ — 11½	...	...
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	6 %	8 %	16 — 17	16 — 17	16⅞	16½
3,000	Do. do. do. 7% Pref.	10	7 %	7 %	7 %	17 — 18	17 — 18	17½	17
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	...	4½%	109 —114	109 —114	...	...
56,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	10 %	10 %	23 — 24	23 — 24	23⅞	23¼
300,000	Do. do. do. 4 % 1st Mort. Debs.	100	...	...	...	... — ...	105 —107	106½	...
37,500	†Liverpool Overhead Railway, Ord.	10	1 %	1½%	2⅞%	14½ — 14½	14 — 14⅛	...	...
10,000	† Do. do. Pref., £10 paid	10	5 %	5 %	5 %	17⅛ — 17⅝	17⅛ — 17⅝	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	20 %	15 %	38 — 41	38 — 41	39½	...
150,000	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	102 —105	104 —107	...	...
54,000£	Waterloo and City Railway, Nos. 1 to 54,000, £6 paid ...	10	...	...	...	8 — 8½	8 — 8½	...	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.
Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7½%; 1890—6%

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5⅞—6¼.
Electric Construction Corporation, 6 % Debentures, 102—105.
House-to-House Company (£5 paid), 3¾—4.
Do. do. 7 % Preference, of £5, 8—8½.
Do. do. 4½% Debentures of £100, 109—111.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 9—9½; 1st Preference Cumulative 6 %, £5 (fully paid), 7½—8.
Liverpool Electric Supply, £5 (fully paid), 7⅞—8¼.
London Electric Supply Corporation, £5 Ordinary, ⅜—1.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 7½—8.

Bank rate of discount 2 per cent. (February 22nd, 1894).

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

THE UTILISATION OF WATER-POWER, ESPECIALLY WITH A SMALL FALL, WITH SOME EXAMPLES OF PLANTS FOR THE GENERATION OF ELECTRICAL ENERGY. By ALPH. STEIGER. (Paper read May 28th, 1896.)

THE cheap production of electrical energy is generally recognised to be one of the chief aims of modern engineering science.

Nature has provided us in water-power with one of the best possible agents for realising this object, and I trust that, in bringing the subject of the utilisation of this free gift of Nature before the members of the Institution of Electrical Engineers, I shall be able to convince them that the water-powers of this country, if judiciously utilised, are capable of rendering them great service.

In my own country—Switzerland—the electrical engineer is co-operating cordially with the water-power engineer, and electrical installations are rapidly increasing in number. The successful electrical transmission of power to points far distant from its source has been the chief factor in this development.

The idea prevails that considerable fall is required to obtain water-power; but it is my desire to show and *to prove*, in the following remarks, that excellent results are obtainable also with a very low fall—a fall of even less than 3 feet.

Small falls are more frequently met with in this country than high falls, and will, therefore, have more particular attention in this paper than the high falls found in mountainous districts. The description of a few turbine plants under low falls, some of which are applied to the generation of electrical energy, will be of special interest.

During a long experience in constructing turbines and designing complete plants, I have found that the most difficult were always those connected with the utilisation of a low fall. These difficulties consist chiefly in the variation within very wide limits of both the quantity of water and the fall, while a constant power, and in most cases a constant speed, is of great importance.

Generally speaking, the real agent in water-power is gravity, and the water is simply the medium to transmit the action of gravity on to the motor which converts it into mechanical work. The action of gravity can take either the form of dead weight, or of pressure, or of velocity, sometimes called kinetic energy. A very high efficiency is obtained from motors in which the water acts by dead weight or by pressure; but the slow speed of the water-wheels, and the complicated mechanism of the pressure engines render them unsuitable for the purpose of generating electricity; moreover, motors worked by weight or by pressure are only advantageous when working under a high fall.

The kinetic energy is the only form in which the gravity can be applied advantageously to the performance of mechanical work under a small fall. The motors using it in this form are the common undershot wheel, the Poncelet water-wheel, and the turbines.

It will be sufficient for the purpose of this paper to give the efficiency of the various types of water motors for any fall, without going into a detailed description of those which are unsuitable for driving dynamos. The efficiency of the motors, with the fall for which they are adapted, is as follows:—

Fall. Feet.	Efficiency of water-wheel.	Per cent.	Efficiency of turbine. Per cent.
1 to 5	Ordinary undershot ...	25 to 30	70 to 75
	Poncelet	65 to 70	
	Sagebien	65 to 75	
5 to 8	Low breast	30 to 50	75 to 80
8 to 15	High breast	60 to 75	75 to 80
15 to 50	Overshot wheel ...	65 to 75	75 to 80
Above 50	Pressure engine ...	75 to 85	75 to 80

These figures show the interesting fact that, the smaller the fall is, the greater is the gain in power over the old-fashioned water-wheels. Although the smallest fall which would reasonably be utilised by a turbine is at least 2 feet 6 inches, I will show by some examples that, by a turbine suitably constructed and carefully adapted, useful power is still obtained under a fall of only 1 foot or a little over.

The great variety of fall, water supply, local conditions, and special requirements, of necessity demands a variety of types of turbines.

Turbines are classified, according to the manner in which the water acts in them, into—

(*a*) "Impulse," or "action," turbines, and
(*b*) "Reaction" turbines;

and according to their construction, into—

(*a*) Parallel flow turbines,
(*b*) Radial flow turbines,
(*c*) Mixed flow turbines.

There is an essential difference between the "impulse" turbine and the "reaction" turbine, as indicated by the form of vanes illustrated in the diagrams figs. 1 and 2.

The "impulse" turbine, as usually constructed, must run clear of the tail water, its buckets being only partially filled with water. It requires a constant fall, with constant level of the water in the head

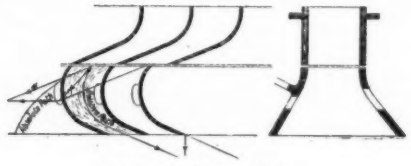


Fig. 1.—Vanes of "Action" Turbine.

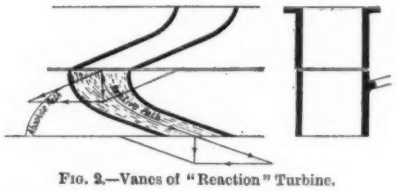


Fig. 2.—Vanes of "Reaction" Turbine.

and tail race, but its efficiency is not affected by the greatest variation of the water supply.

On account of this quality, it can be built as partial injection turbine, to utilise high falls with a very small water supply. If constructed as "partial injection turbine," its diameter can be chosen so as to give just the desired number of revolutions. This is extremely convenient for driving dynamos, which can thus be connected direct with the shaft of the turbine, doing away with intermediate gearing or belt drives. An instance of this kind is the turbine plant now

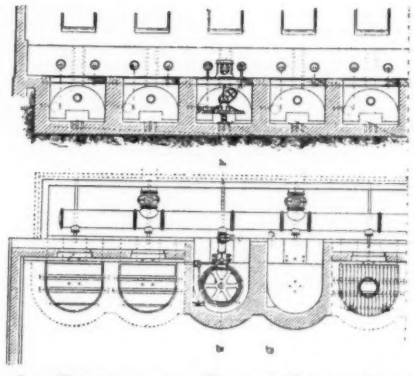


Fig. 3A.—Turbines at the Falls of Foyers, Scotland.
(The British Aluminium Company, Limited.)

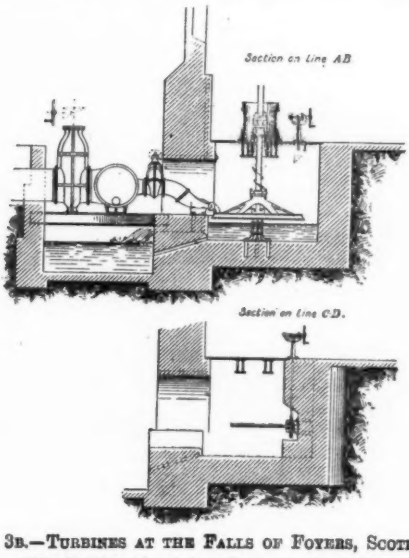


Fig. 3B.—Turbines at the Falls of Foyers, Scotland.
(The British Aluminium Company, Limited.)

being erected by Messrs. Escher, Wyss & Co., of Zurich, at the Falls of Foyers, for the British Aluminium Company, Limited. This plant consists of five "impulse" turbines with vertical shaft, with partial injection, each giving 700 brake horse-power, working under a fall of 350 feet. The dynamos are required to run at 140 revolutions per minute, and to obtain this speed the turbines were given a diameter of a little over 9 feet.

Partial injection turbines under a high fall are sometimes fixed on a horizontal shaft, and can thus be coupled direct to the armature spindle of a dynamo by means of an isolating coupling. This mode has been adopted, amongst numerous other plants, for the electric lighting installation of Davos, in Switzerland, which consists of three horizontal patent turbines of 200 B.H.P. each, working under a fall of 330 feet, and running at 400 revolutions per minute. The turbines have a diameter of 40 inches. As a contrast to these turbines of large power and small diameter, and to show the adaptability of the

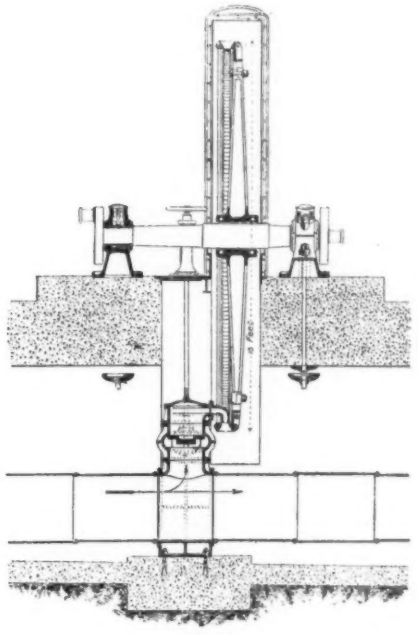


Fig. 4.

Turbines of the Chauxdefonds Waterworks, Switzerland.

partial injection turbine to special requirements, the 140 H.P. turbines of the waterworks in Chauxdefonds may be mentioned. These work under a fall of only 170 feet, but as they are driving pumps at the low speed of 60 revolutions, they had to be made of a diameter of 15 feet.

Great as the advantages of the "impulse" turbines are under the conditions above mentioned, their use under very low falls is limited, firstly, owing to the reason already given that they must run clear of the tail water—a condition which can seldom be realised in a flat country like this; and, secondly, because they run at a slower speed than a "reaction" turbine under the same fall. Although "impulse" turbines are now built to run in the tail water without considerable loss of efficiency, the reduction of power in proportion to the reduced fall, and the quantity of water accordingly reduced, together with the reduced speed, excludes them in the majority of low and varying falls.

The ideal turbines for low and varying falls are *the "reaction" turbines.* They are generally placed in a level with the tail water, or, if local conditions require them to be placed above tail water, connected with it by a suction tube. They run at a higher speed for the same fall, or the same diameter, than an "impulse" turbine, and their efficiency is not affected by the immersion in the tail water. The principal objection raised against "reaction" turbines in general is that their efficiency is greatly reduced when working at part gate. This is indeed the case with many of the reaction turbines known in this country, which give a very poor efficiency at part gate, especially at less than half gate. The continuity of flow of the water through the buckets is essential to a good efficiency. Only in a few reaction turbines is this condition fulfilled to such an extent that within very wide limits of the water supply the efficiency is not perceptibly reduced.

The utilisation of a small and varying fall, with a varying quantity of water, is a very difficult problem for the water-power engineer.

The turbine for a given power under a low fall is larger and runs slower than one of the same power under a higher fall; it is, therefore, heavier and more costly, and requires heavier gearing, entailing a greater loss of power through friction.

A high speed is desirable, especially for driving dynamos; but attempts to increase the speed of the turbine by reducing its diameter may easily result in an inferior efficiency. The efficiency should be as high as possible in consideration of the greater cost of a water-power plant with a low fall; but the proportions within which such a fall and the quantity of water varies is mostly so great that it is almost impossible to obtain the highest efficiency when the water supply is diminished, *i.e.*, when a high efficiency is most wanted. The maintenance of a *constant* power with a *constant* speed under variation of fall and quantity of water in large proportion can, if at all, only be

obtained by sacrificing some efficiency. The hydraulic losses must be reduced to a minimum by the most careful construction of the turbine in its essential parts, and it is needless to say that no standard size or type of turbine will fulfil all these conditions by simply consuming all the available water

Even the arrangement of the turbine chamber is of influence on the results, and requires special attention. On a careful judgment of the local conditions depend the economy and the success of a plant. Unsatisfactory results in water-power plants are caused just as much, or oftener, by bad judgment of the local conditions than by the inferiority of the turbine.

In by far the most cases of low falls, incidental to flat countries, an abundance of water corresponds with a reduction of the fall. The power of a turbine calculated for the normal fall would be reduced, for the time, when an abundance of water reduces it, and, as a consequence, water would be wasted, while the power obtained is insufficient. These cases are, unfortunately, of frequent occurrence. On the other hand, if the turbine is constructed to give off the required power under the reduced fall, it must be partially closed for the diminished water supply with the normal fall, whereby the efficiency would be reduced just when it should be highest, if economy is at all the chief object of a turbine plant.

The manner in which a high efficiency can be maintained for a diminished water supply is to subdivide the turbine into several compartments, each of which represents a complete turbine. This arrangement has been adopted by Fourneyron for his well-known outward flow turbine, and in the modern *Jonval turbine*. The Fourneyron turbine is provided with a cylindrical gate, which is moved vertically, whereby each compartment is opened or closed. This type has been adopted for the large power plant on the Niagara Falls, but on the European Continent they are seldom used. Their efficiency is very good, but, owing to the narrowness of the buckets, they are easily choked.

The Jonval turbine is a parallel flow turbine, and is, for large variations of the fall and quantity of water, subdivided into two or more concentric compartments. A subdivision in this manner renders it possible to maintain not only the power, but also *the speed*, under a varying fall within very wide limits.

The description of a Jonval turbine installation which I supplied for the Brantham Mills, near Manningtree, in Essex, here illustrated, will show that a very small and varying fall can be utilised with great

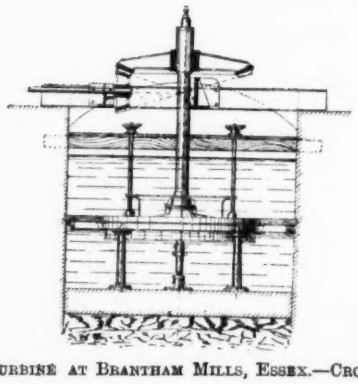


Fig. 5a.—Turbine at Brantham Mills, Essex.—Cross Section.

advantage to obtain nearly a constant power. The local conditions and requirements are most remarkable and interesting. The power is used to drive a modern flour mill, in which the maintenance of a regular speed is of equally great importance as for driving an electrical plant.

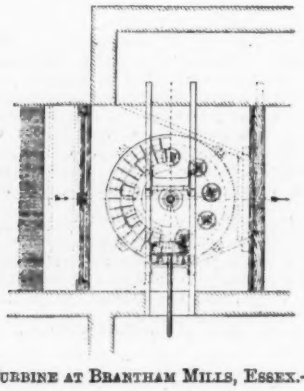
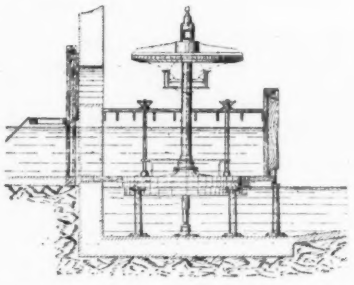


Fig. 5b.—Turbine at Brantham Mills, Essex.—Ground Plan.

The river Stour is a tidal river, with a maximum fall at ebb tide of 4 feet 10 inches, while at high tide the fall is *nil*. The water is supplied partly by the river itself coming down from the hills of Cambridgeshire, and partly by the rising tide filling the river-bed above the mill for a considerable length. The power required is 40 actual H.P., and it was stipulated that this power should be maintained down to a fall of 40 inches. On starting the turbine, it was shown, however, that it drove the mill at full capacity and at full speed under a fall reduced to 32 inches. The full power is available during 16 hours of each day, while during six further hours the power corresponding to a fall reduced down to about 1 foot is still utilised for driving a part of the machinery. Comparing the useful power obtained from this varying fall by the new turbine during 24 hours with that obtained by the undershot water wheel previously working, it is nearly six times larger.



Turbine at Brantham Mills, Essex.—Longitudinal Section.

Fig. 5c.

The turbine consists of only two concentric rows of buckets; the inner one is provided with gates, which are opened or closed by hand wheels, an automatic governor not being generally used in flour mills. The outer row of buckets is just large enough to give the full power required under the maximum fall. As the fall is decreasing by the rising tide, the gates of the inner row of buckets are gradually opened to make up the power by an increased quantity of water, and the more water is passing through the buckets of the inner row the more it acts on a reduced mean diameter, thus maintaining also the proper speed without perceptible loss of efficiency.*

(To be continued.)

ALTERNATE CURRENT DYNAMO-ELECTRIC MACHINES.†

By J. HOPKINSON, F.R.S., and E. WILSON.‡

(*Continued from page* 709.)

The machines were run under conditions set forth in Table I., and the curves are given in figs. 5, 6, 7, 8. An electromotive force curve,

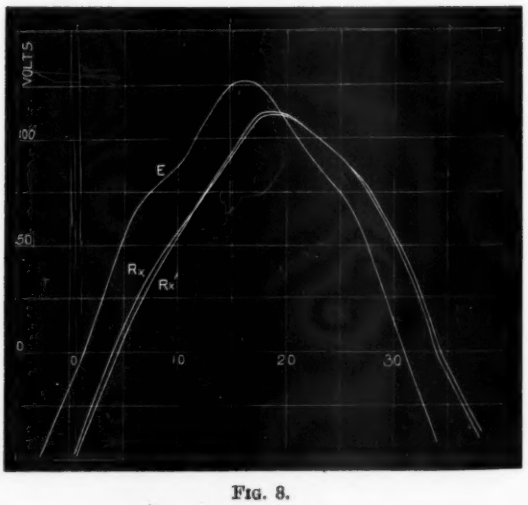


Fig. 8.

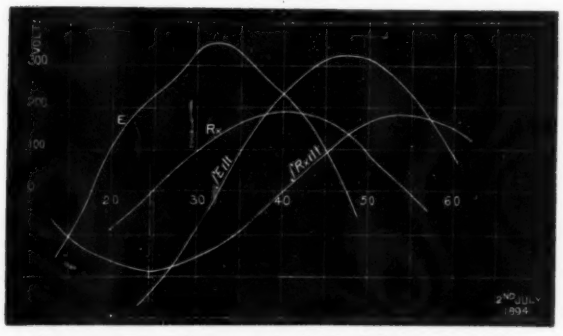
e, was observed with no current in the armature, and a curve of

* The outside diameter of this turbine is about 10 feet, and it runs with 24 revolutions per minute.

† Read before the Royal Society, May 2nd, 1895.

‡ The large majority of the experiments herein described were made in the summer of 1893 and a considerable part of the paper was then written. We have to thank Mr. F. Lydall, one of the student demonstrators at King's College at that time, for much assistance.

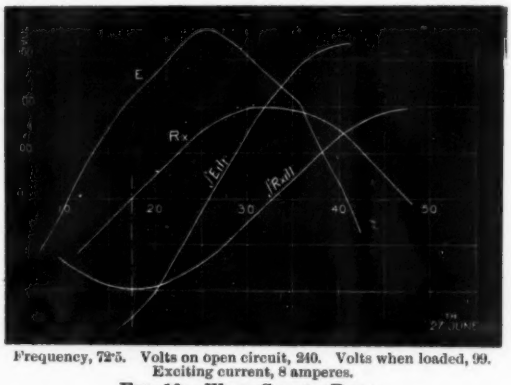
potential difference was taken between the brushes with the alternator loaded on a non-inductive resistance. B x is this curve *with* variations in the exciting current, and B x' *without* variations, in each case corrected for the resistance of the armature. Figs. 6 and 7 show the curves of actual electromotive force, B x and B x', when the current



Frequency, 72·5. Volts on open circuit, 240. Volts when loaded, 92. Exciting current, 8 amperes.

FIG. 9.—WITHOUT COPPER RINGS.

in the magnet winding is allowed to vary and when its variations are stopped. It will be seen that they do not differ a great deal. What currents are stopped in the magnet winding no doubt turn up in the substance of the cores themselves and have an effect not differing greatly. Curve E represents electromotive forces observed. B x represents the potential difference taken between the brushes and corrected for the resistance of the armature, with the alternator working on a non-inductive resistance *with* variations in the exciting current.

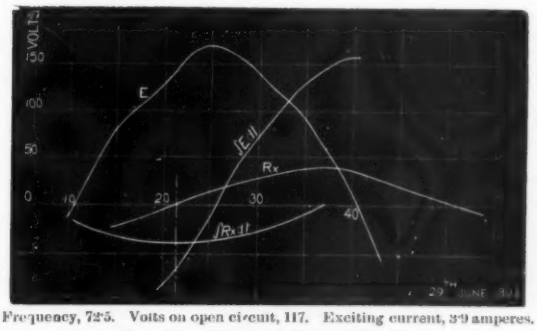


Frequency, 72·5. Volts on open circuit, 240. Volts when loaded, 99. Exciting current, 8 amperes.

FIG. 10.—WITH COPPER RINGS.

B x' *without* such variations in each case. The induced currents are in either case adequate to nearly stop the variation of induction. Fig. 8 shows the same thing.

An exploring coil was wound and placed on one of the magnet limbs and the electromotive force in it was observed in terms of the time for the various positions of the exploring coil, marked 1, 2, 3, 4, 5, in fig. 1. Both the amplitude and the epoch varied with the position of the coil, but, in all cases, the periodic time was half the periodic time of the machine. It does not seem worth while to publish the curves connecting electromotive force and time.



Frequency, 72·5. Volts on open circuit, 117. Exciting current, 3·9 amperes.

FIG. 11.—WITHOUT COPPER RINGS.

Lastly, we tried to exaggerate the effects; for this purpose we introduced plates of copper, $\frac{1}{8}$ inch thick, in the form of two flat rings between the pole faces and the armature. Curves 9, 10, 11, 12, give the results for two different currents round the magnets with the copper plates in and the copper plates absent. A comparison shows that the copper plates do not make a great deal of difference. The principal effect is to diminish the current induced in a coil on the magnet placed at position 5, fig. 1, close behind the copper plate.

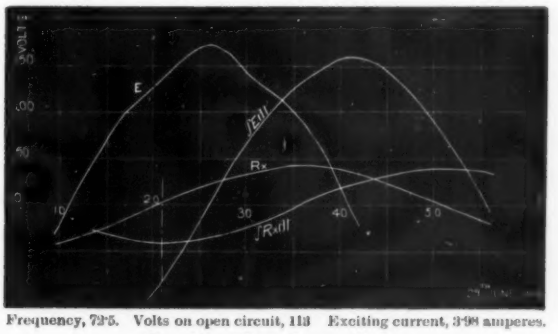
TABLE I.

Fig.	Frequency.	$* \frac{b}{a}$. With variations in current in magnet winding.	$* \frac{b}{a}$. Without variations in current in magnet winding.	Amperes ("mean") per armature bobbin. With variations in current in magnet winding.	Amperes ("mean") per armature bobbin. Without variations in current in magnet winding.	Exciting current in winding on magnets. Amperes. Amperes when normal.	Exciting current in winding on magnets. Amperes. Maximum variation both sides from normal.	Remarks.
							Per cent.	
5	92·3	·255	...	20	...	8	...	
	97·7	·149	...	15	...	7	...	
6	95	·13	·147	13·6	13·6	7	22	External resistance altered so as to give same current
6	95	·104	·147	14·1	13·6	7	22	External resistance same in each experiment
7	9·2	·093	·085	8·9	9·1	6	21	External resistance same in each experiment
8	11·7	·05	·035	17·6	17·6	16	20	External resistance same in each experiment

* $a = \frac{1}{2}\int_0^T {}_2\, \text{E}\, dt - \int_{\text{E}=0}^{x=0} \text{E}\, dl$ = ordinate of curve A when $x = 0$.

$b = a - \frac{1}{2}\int_0^T {}_2\, \text{B}\, x\, dt$ = difference of ordinates of curves A and B when $x = 0$, which should be zero on the usual theory.

It may be inferred that in this machine there is conductivity enough in the magnet cores to have in large measure the effect indicated, and that the effect cannot be greatly diminished by compelling the magnetising current to be constant in the magnet coils, nor can it be greatly increased by exaggerating the currents induced about the magnets by intentionally introducing additional conductivities around them. The effect of each is merely to alter the place where the currents occur.



Frequency, 72·5. Volts on open circuit, 113 Exciting current, 3·98 amperes.

FIG. 12.—WITH COPPER RINGS.

Recently machines have been built, with finely divided pole-pieces to the magnets by Messrs. Mather & Platt and by the British Thomson-Houston Company.

It was obviously desirable to obtain a verification with a machine of totally different construction. For this purpose we had available the first model made of the alternating machines manufactured by Messrs. Mather & Platt. It has an iron core in the armature which projects and extends beyond the armature coils. It was treated in exactly the same way as the Siemens's machines but with a fairly full load. The results are shown in fig. 21, from which it will be observed that the total induction actually observed when the machine is loaded is about 11 per cent. below the induction inferred from the electromotive force on open circuit.

II.

The following experiments were primarily made for the purpose of determining the efficiency of the machine, but they will be seen in Section III. to have an important bearing upon the principal subject of this paper.

For the purpose of finding the efficiency of the alternators, when running as generator and motor,* the two armatures were rigidly mechanically coupled together, the leading machine being generator, and were connected in series with a non-inductive resistance, r, and a Kelvin ampere balance, C, as shown in fig. 13. The potential difference of the generator was measured at different epochs by means of the Kelvin quadrant electrometer, Q, and the contact maker, K, the potential applied to the electrometer being reduced by the non-inductive resistances, r_1, r_2. For corresponding epochs a curve of potential was taken across r, this gives the current passing between the machines and also the difference of potential difference between motor and generator.

The power difference, or loss in the combination, was supplied by a shunt motor through shafting and belts, and was determined by observing the watts supplied to the motor when driving the shafting, the alternator belt being removed, and then observed the watts taken to drive the alternator when loaded—the speed being the same in each case. The difference gives the power absorbed by the combination.

It was found that the watts required to drive the shafting alone were 1,681; the watts required to drive the shafting and alternators when excited, but not loaded, were 2,479, the difference being in part due to currents induced in the metal frames of the armature.

(To be continued.)

NEW PATENTS AND ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Compiled expressly for this journal by* W. P. THOMPSON & Co., *Electrical Patent Agents*, 322, *High Holborn, London, W.C., to whom all inquiries should be addressed.*]

NEW PATENTS.—1896.

10,669. "An electrical variable speed gear." A. G. NEW. Dated May 18th.

10,670. "An electrical variable speed gear." A. G. NEW. Dated May 18th.

10,698. "Improvements in or applicable to electric alarum apparatus." H. C. BIRD. Dated May 18th.

10,718. "Improvements in the manufacture of positive lead electrodes for electrical accumulators." H. O. TUDOR. Dated May 18th.

10,720. "Improvements in electrically braking railway vehicles." I. A. TIMMIS. Dated May 18th.

10,772. "Improvements in starting and stopping devices for electrically operated elevators." OTIS ELEVATOR COMPANY, LIMITED. (Otis Bros. & Co., United States.) Dated May 19th.

10,781. "Improvements in apparatus for the application of electricity to vehicles driven by mechanical means." H. J. DOWSING. Dated May 19th.

10,788. "Improvements in electric arc lamps." E. J. BAGNALL. Dated May 19th.

10,803. "Improvements in or applicable to apparatus for heating by electricity." E. DAVIES. Dated May 19th.

10,804. "Improvements in electric railways." H. H. LAKE. (E. H. Johnson and R. Lundell, United States.) Dated May 19th.

10,811. "Improvements in the production of electrodes suitable for secondary batteries." A. J. MARQUAND and E. HANCOCK. Dated May 19th.

10,816. "Improvements in electric measuring instruments." J. DEVONSHIRE. (E. Thomson, United States.) Dated May 19th.

10,817. "Improvements in and connected with electric brakes for electrically propelled vehicles." J. DEVONSHIRE. (W. P. Potter, United States.) Dated May 19th.

10,818. "Improvements in contact making and breaking devices at drawbridges in the overhead circuit of electric tramways." J. DEVONSHIRE. (W. B. Potter, United States.) Dated May 19th.

10,846. "Improvements in or relating to magnetically affecting the counter electromotive force of the voltaic arc of an electric arc lamp." W. P. THOMPSON. (C. L. Coffin, United States.) Dated May 19th.

10,906. "Improvements in and connected with electrical traction." W. KINGSLAND. Dated May 21st.

10,948. "Automatic gear for making or breaking, or both making and breaking electrical contacts at given times, which times may also be varied at will." F. BROWN and C. H. OFFORD. Dated May 21st.

10,949. "Improvements in the application of electrical motive power to cycles and road vehicles." R. O. ALLSOP. Dated May 21st.

10,988. "Electro-magnetic gearing." D. COOK. Dated May 21st.

10,993. "Improvements in electric incandescent lamps." E. BAILEY and J. M. SYMINGTON. Dated May 21st.

11,035. "Improvements in the manufacture of electric-insulation tubing and electric insulators." F. G. TREHARNE. Dated May 21st.

11,133. "Improvements in or connected with apparatus for the electrolytic decomposition of liquids." G. BELL and G. W. BELL. Dated May 22nd.

11,162. "Electric alarm apparatus." F. W. GOLBY. (H. Winter.) Dated May 22nd.

11,176. "Improvements in electrical boilers for heating water and other liquids." J. CHAMBERS. (Date applied for under Patents, &c., Act, 1883, Section 103, December 5th, 1895, being date of application in New Zealand.) Dated May 22nd.

11,212. "Improvements in dry cells for galvanic batteries." T. CLARK. Dated May 22nd.

11,216. "Improvements in electro-chemical apparatus." C. DAWSON. (F. Mansa, Austria.) Dated May 22nd.

11,230. "Improvements in electrical regulating apparatus for arc lamps." H. PIEPER FILS. Dated May 22nd.

11,232. "Improved electric current conducting apparatus for electric railways." C. F. P. STENDEBACH and O. H. LINKER. Dated May 22nd.

11,249. "Improvements in the method of and apparatus for driving electric cars." W. GRIFFIN. Dated May 23rd.

11,320. "Improvements in electric railway signals." W. M. KLEES. Dated May 23rd.

11,338. "Improvements in electrodes for electrolytic purposes." E. A. G. STREET. Dated May 23rd.

ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Copies of any of these Specifications may be obtained of* Messrs. W. P. THOMPSON & Co., 322, High Holborn, W.C., *price, post free*, 8½*d.* (*in stamps.*)]

1895.

8,507. "Improvements in and relating to electric cut-outs." J. A. JECKELL. Dated April 30th, 1895. Relates to a combined fusible cut-out and disconnection plug, and consists of a fuse wire mounted in an insulating carrier, or handle, and so arranged that it can be inserted between two clips forming the terminals of the cables to be connected or disconnected. 1 claim.

8,573. "Improvements in electric cables and in their manufacture." W. S. SMITH and W. P. GRANVILLE. Dated April 30th, 1895. Relates to the construction of a cable with a longitudinal air space provided in the insulation; for example, the insulation is made in the cross-sectional form of two crescents having their concave sides adjacent, two wires being embedded in each crescent near the concave side. 4 claims.

8,664. "Improvements in electric arc lamps." R. E. B. CROMPTON and E. A. N. POCHIN. Dated May 1st, 1895. Relates to arc lamps in which the movements of the carbons are controlled by flexible connections and the propelling force causing the feed is due to gravity. The regulation is effected through the agency of a brake wheel having a flexible band on its periphery, one end being attached to a lever vibrated by means of two solenoids, one of which is a shunt, the other being a series coil. The other end of the flexible band is attached to a weight. The invention consists of numerous improvements in construction details, mainly for cheapening the manufacture. 7 claims.

1896.

3,093. "Improvements in controllers for dynamo-electric machines." J. DEVONSHIRE. (A communication from W. H. Knight and J. W. Darley, U.S.A.) Dated February 11th, 1896. Relates to a device for changing two or more machines from series to parallel connection. A resistance is provided which is included in the circuit during the time the successive changes on the connections are made. 9 claims.

3,094. "Improvements in regulating phase relation of alternating currents." J. DEVONSHIRE. (A communication from E. J. Berg, of Schenectady, U.S.A.) Dated February 11th, 1896. Relates to a method of maintaining the current in phase with the electromotive force, and in which opposing electro-magnetic devices are used, the opposition being balanced when the current and electromotive force are in phase. When the opposing force is not balanced it acts to restore the phase relationship and so produce a balance. 5 claims.

* This is the same method of test which has been applied to direct current machines (see *Phil. Trans.*, R.S., 1886, p. 331).